STUDIES ON KEY PESTS OF OKRA, *Abelmoschus esculentus* (L.) Moench IN RELATION TO POPULATION DYNAMICS, CROP LOSSES AND CONTROL

By

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M.Sc. (Agri.)

DISSERTATION

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*To Late Shri. Sane Guruji (Pandurang Sadashiv Sane, 24-12-1899 to 11-6-1950) Because Of Whom I Came To Know Little About A **Mother**, This Thesis Is Sincerely Dedicated.*

CANDIDATE'S DECLARATION

I hereby declare that the entire work embodied in this thesis or a part thereof has not been previously submitted by me for a Degree or Diploma of any University or Institute

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CERTIFICATE I

This is to certify that Shri **DAYANAND GOVINDRAO MORE** has satisfactorily prosecuted his course and research for a period of not less than four semesters and that the dissertation entitled **"STUDIES ON KEY PESTS OF OKRA *Abelmoschus esculentus* (L.) Moench IN RELATION TO POPULATION DYNAMICS, CROP LOSSES AND CONTROL"** submitted by him is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I also certify that the thesis or a part thereof has not been previously submitted by him for a degree of any university.

PLACE : PARBHANI.
DATE : 21 / 6 /2003

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Research Guide

CERTIFICATE -II

This is to certify that the dissertation entitled **"STUDIES ON KEY PESTS OF OKRA *Abelmoschus esculentus* (L.) Moench IN RELATION TO POPULATION DYNAMICS, CROP LOSSES AND CONTROL"** submitted by **Shri. DAYANAND GOVINDRAO MORE** to the Marathwada Agricultural University, Parbhani in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (Agriculture)** in the subject of **AGRICULTURAL ENTOMOLOGY** has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

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Dmore

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D. G. MORE

LIST OF ABBREVIATIONS

@	-	At the rate of
%	-	Per cent
/	-	Per
a.i.	-	Active ingredient
AM	-	Ante meridian
b	-	Regression coefficient
BSS	-	Bright sunshine hours
CBR	-	Cost benefit ratio
CD	-	Critical difference
cm	-	Centimeter (s)
cm^2	-	Square centimeter (s)
conc.	-	Concentration
DAS	-	Days after sowing
EC	-	Emulsifiable concentrate
et al.	-	And associates
Fig.	-	Figure (s)
g	-	Gram
G	-	Granules
ha	-	Hectare(s)
hr	-	Hour
i.e.	-	That is
kg	-	Kilogram (s)
lit.	-	Litre (s)
m	-	Metre (s)
M.S.	-	Maharashtra State
m^2	-	Square meter (s)
max	-	Maximum

min.	–	Minimum
ml	–	Milliliter (s)
MW	–	Meteorological week
N	–	North
N.S.	–	Non significant
No.	–	Number
°C	–	Degree centigrade
PM	–	Post meridian
ppm	–	Parts per million
q	–	Quintal (s)
r	–	Correlation coefficient
RBD	–	Randomized block design
resp.	–	Respectively
RH	–	Relative humidity
Rs.	–	Rupees
S.E.	–	Standard error
SC	–	Soluble concentrate
SL	–	Soluble liquid
Spp.	–	Species
Temp.	–	Temperature
Var.	–	Variety
Viz.	–	Namely

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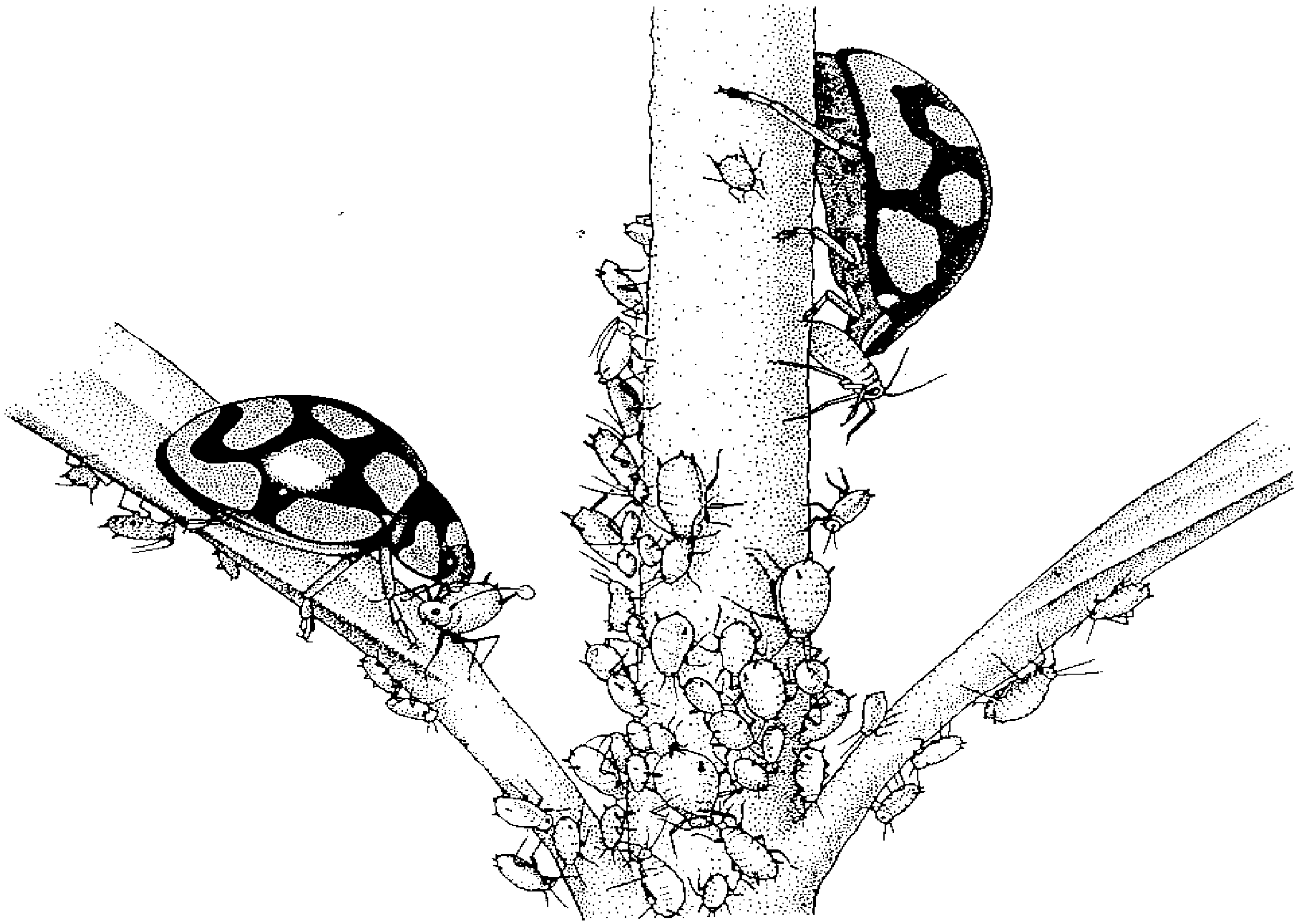


INTRODUCTION

CHAPTER I

INTRODUCTION

Vegetables not only adorn the table but also enrich the health of man. They form the most nutritive menu of human and tone up his energy and vigour. Regular use of vegetables supplies many of the most essential health building and protecting substances, such as vitamins and minerals, carbohydrates and proteins, which are wanting in other food materials.

Okra, *Abelmoschus esculentus* L. Moench, also called as Lady's finger or *Bhendi*, belongs to family Malvaceae. It is a major vegetable being cultivated all over India particularly in the states of Uttar Pradesh, Madhya Pradesh, Karnataka, Gujrat and Maharashtra. It occupies an area of 25,000 hectares in the state of Maharashtra with 1,50,000 MT production (Anonymous, 2000). In Maharashtra it is largely grown in Pune, Nagpur, Nashik, Jalgaon, Ahmadnagar, Amravati, Aurangabad, Parbhani, Satara and Osmanabad districts.

Tender fruits of okra are used as vegetable. The root or stem of wild okra are used for cleaning the *Gur* or *Khand* or raw sugar. Fruits of okra with their fibrous stalks are used in paper industry. Fruits of okra contain salts of potash, lime and magnesium. Fruits also contains iodine. Fruits has high medicinal value and is useful in fevers, catarrhal attacks, irritable states of the genito-urinary organs. In the cases of chronic dysentery, the bland mucilage is most beneficial and generally given in the form of soup.

The crop has two distinct growing stages i.e. vegetative stage and fruiting stage. The pest problems of okra are more or less similar to that of cotton crop. It is usually heavily attacked by sucking pests right from the early seedling stage to last fruit harvesting. The important among them are jassids (*Amrasca biguttulla biguttulla* Ishida); aphids (*Aphis gossypii* Glover) and whiteflies (*Bemisia tabaci* Gennadius). Jassid attack causes the leaves to curl upwards along the tips and margins and to develop necrotic areas, which extend over entire leaf surface resulting in 'hopper burn'. Nymphs and adults of aphids and whiteflies suck the sap and reduce vigour of the plants besides whiteflies act as vector in transmitting viral diseases. Heavy infestation of these sucking pests in young stage results in stunted growth and gradual death of the plant.

In the later stages, the crop is severely attacked by shoot and fruit borer, *Earias vittella* Fab. Larva bores the growing shoot of okra plant prior to fruit formation resulting in withering and drying of shoot. On availability of fruits, larva starts feeding on it and thus causes direct loss of yield. Besides, the affected fruits are loose market value heavily.

Population dynamics is the study of the growth and structure of populations, together with the factors that regulate their size and cause fluctuations in their density. Meteorological factors (temperature, rainfall, relative humidity, light period and intensity etc.) are among the most important environmental -resistance factors that affect plant pests. Thus the studies on population dynamics give us an idea of the environmental factors that regulate cyclic occurrence of the pests. The population dynamics helps in planning need based application of insecticides as it clearly reveals the peak activity as well as insect free periods during crop growth.

Judicious use of chemicals is of particular importance. It gives a good kill of the pest and by avoiding excessive use of chemicals a critical level of host population always remains unharmed, which harbours the natural enemies like parasitoids and predators (Smith, 1969). Now a days many insecticides are available in the market for control of okra pests. Despite repeated sprayings of various insecticides, control of these pests still remains a problem. Hence, for the control of sucking pests some recently developed insecticides as imidacloprid and thiamethoxam from the first generation and second-generation neonicotinoid group, respectively were evaluated as seed dressers along with conventional seed dresser (carbofuran). Also, the insecticides when applied as seed dressers are generally safer to the predators, parasitoids and other beneficial species of the insects. Some newer insecticides as spinosad and mixture of profenophos and cypermethrin (Polytrin C $^{(R)}$) were tested along with conventional insecticide, monocrotophos for the control of *E. vittella*.

It is necessary to consider the cost benefit ratio of pest management strategies because it decides its acceptability for implementation. Hence the economics of various treatment applications was worked out.

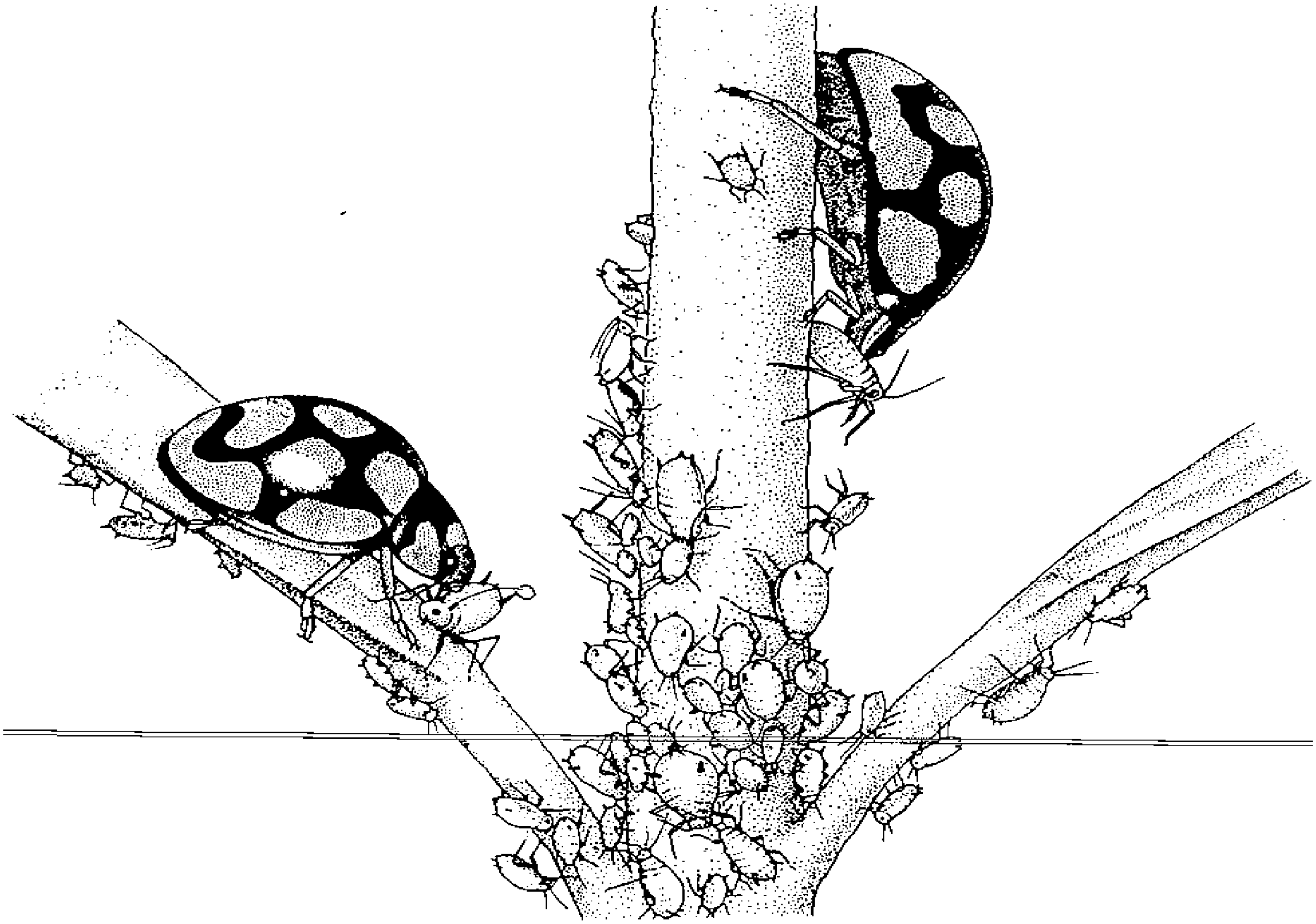
Nevertheless, sprayings of insecticides have an effect on the natural enemies. Hence, the effect of different insecticidal treatments on the larval parasitization of *E. vittella* is studied.

The assessment of crop losses due to pests is a pre-requisite for any planned programme of crop protection. It helps in the prediction of crop production and development planning for further production. Pradhan (1969) stated that in the absence of correct estimate of losses due to insect pests, various "guess estimates" have been made by scientists and administrators, but none of them is backed by adequate data collected on large scale.

Keeping in mind the above points, investigations were carried out on the following aspects.

1. To study the population dynamics of key pests of okra.
2. To study the efficacy of some newer insecticides against key pest of okra.

3. To study the economics of various treatment applications in okra pest management.
4. To study the effect of different insecticidal treatments on parasitization of *E. vittella*.
5. Crop loss assessment due to key pests during various growth periods of okra.



REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Okra (*Abelmoschus esculentus* (L.) Moench), commonly known as 'bhendi' is cultivated all over the country during spring, summer, and *kharif* seasons. A number of insect pests are reported to cause heavy economic damage to this crop of which, jassid (*Amrasca biguttulla biguttulla*) and fruit borer (*Earias vitfella*) are most serious. These pests can cause upto 69 per cent loss in yield (Rawat and Sahu, 1973). Besides jassids and fruit borers, aphids (*Aphis gossypii*) and whitefly (*Bemisia tabaci*) are important pests of okra and can cause appreciable damage. All these are reported as pests of cotton crop. Therefore, voluminous literature is available on the management of the pests with conventional insecticides, collectively with other species of bollworms.

At present, most of the recommended insecticides used against pests of okra are less effective in suppressing the pest populations. Farmers therefore, often use insecticides indiscriminately with higher dosages resulting in increased cost of production and other problems. Hence in present studies certain newer insecticides as seed dressers and foliar applications were tested for their efficacy against the pests of okra along with their economics.

In order to fall in line with the experiment conducted in the present investigation, the pertinent review of recent literature is presented in this chapter under following headings.

2.1. Population dynamics of key pests okra

2.2. Efficacy of insecticides against pests of okra

2.3. Effect of different insecticides on marketable fruit yield of okra

2.4. Economics of various treatment applications in okra pest management

2.5. Parasitization of *E. vittella*.

2.6. Crop loss assessment due to key pest of okra.

2.1. Population dynamics of key pests of okra

2.1.1. Population dynamics of sucking pests of okra

Murugesan *et al.* (1977) reported highly significant positive association between maximum temperature and whitefly incidence. They further reported that rainfall and relative humidity were negatively correlated with whitefly incidence.

Lal (1981) observed that whitefly was most abundant from June to August as well as in October on cassava.

Srinivasan *et al.* (1981) reported that rainfall was found to reduce mean density and increase aggregation of *A. biguttulla biguttulla* on okra. The absolute maximum temperature also caused an increase in aggregation.

Lal and Pillai (1982) found significant and positive relationship between maximum temperature and population of whitefly whereas; rainfall and relative humidity were negatively associated, although their relationship was non-significant.

Bhardwaj and Kushwaha (1984) reported peak infestation of *B. tabaci* in October and March. They further reported that the association between whitefly and maximum temperature was positive and significant, while that of relative humidity was negatively significant.

Dhamdhere *et al.* (1985) observed that *A. biguttulla biguttulla* remained active throughout both seasons in *kharif* and summer of 1980-81. Low humidity in 1980 appeared to be conducive to population build-up.

Rao and Reddy (1987) observed whitefly population on cotton from August through December and reported that whitefly population increased from 21st October to 18th November and decreased subsequently upto the end of December during 1984 and 1985. They observed significant negative association between whitefly incidence and all the weather factors.

Latpate (1987) observed whitefly population on cotton from second week of August to the end of December with peak infestation during first fortnight of November. He also found significant and negative association between whitefly incidence and weather factors *viz.*, rainfall, relative humidity, mean temperature and wind velocity.

Faleiro and Rai (1988) studied the relationship between okra yield (q/ha) (Y) and population (x) of *A. biguttulla biguttulla* (nymphs per 3 leaves) in India and revealed the equation $Y = 64.99 - 0.8525x$ and concluded an economic injury level of 4.66 leafhoppers per plant.

Uthamasamy (1988) reported the highest infestation of *A. biguttulla biguttulla* in okra sown in July and observed negative correlation between fruit losses and infestation or leaf damage.

Lal *et al.* (1990) reported *A. biguttulla biguttulla* on 2 weeks-old okra crop which increased with age of crop except 2nd half of the fourth and fifth weeks because of heavy rainfall (61.1 mm), low temperature (< 29°C), high RH (> 78 %) and less sunshine (6.4 hr) which reduced pest population by 72.6 per cent.

In Punjab, in 1986, *A. gossypii* remained active from the 4th week of July to the 3rd week of October on okra. The population peaked at 450 aphids / 30 plants in the 1st week of September (Jamawal and Kandoria, 1990).

Abundance of the cicadellid *Amrasca devastans* on okra was studied in Pakistan during 1986-87. The pest appeared in June and remained active till the end of the crop season. Among various environmental factors, the only significant factor in both years of the study was minimum temperature. A positive correlation was found between maximum and minimum temperature with regard to density of the pest. Neither relative humidity nor rainfall significantly increased or decreased the pest population (Mahmood *et al.*, 1990).

Patel and Rote (1995) studied the seasonal incidence of sucking pests of cotton cv. Digvijay under rainfed condition in Bharuch, Gujrat, during 1979-80 and 1981-81. Results showed that population of *A. gossypii* peaked (43.05 / plant) in the second fortnight of October. The population of *A. biguttulla biguttulla* ranged from 0.59 to 2.78 per plant while *Scirtothrips dorsalis* population ranged from 0.61 to 4.64 per plant.

Pawar *et al.* (1996) reported significant positive correlation of okra jassid and maximum temperature and bright sunshine hours. The crop sown on 15th May and 1st June had a lower incidence of jassids (13.3 to 13.7 /plant).

Patel *et al.* (1997) reported that significant positive relationship was observed among *A. biguttulla biguttulla population* level and maximum temperature (r = 0.76) as well as hours of bright sunshine (*r* = 0.82). The population of the leafhopper increased during monsoon season when temperature remained around 37°C along with at least ten hours of bright sunshine.

In field studies conducted in Haryana, Sharma and Sharma (1997) recorded the number of nymphs of *A. biguttulla biguttulla* on the ventral surface of thirty leaves of ten cotton and ten okra plants at weekly intervals starting from the first week of July. The highest population was observed during the first week of August. Numbers were negatively correlated with the maximum temperature and positively correlated with the minimum temperature and average relatively humidity.

Devasthali and Saran (1997) reported that the infestation period of cicadellid and aphid was 49 days. The mean weekly population density of cicadellid (30-69) on three leaves was greater than that of aphid (18.32 per three leaves). The peak population density of *A. biguttulla biguttulla* (82.56 per three leaves) was greater than that of the aphid (54.94 per 3 leaves).

Jarande (1998) observed that the population of aphid, jassid and whitefly ranged from 0.40 to 23, 0.50 - 39.95 and 0.45 to 0.90 per three leaves per plant. However, he found non-significant relationship between pest incidence and weather parameters studied.

Mahmood *et al.* (1998) studied the incidence of the cicadellid in relation on okra in Pakistan. The population of the pest remained below the economic threshold level for about five weeks after germination. After this, the population crossed the threshold level in early June and remained at the same level until late August. The population of the pest peaked in late July (27.8 redundant /leaf).

Rai and Satpathy (1999) reported that there was gradual increase in jassid population on okra crop sown at different dates upto mid-July. The late sown crop suffered heavily from fruit borer infestation and crops sown in the second week of July recorded maximum fruit damage.

Investigations on seasonal incidence of jassid and whitefly populations on okra carried out in semi-arid region of Rajasthan by Kumawat *et al.* (2000) revealed that the infestation started in the fourth week of July and reached peak in the second and fourth week of September, respectively.

Telang *et al.* (2003) observed very high population of aphids (10.25 to 170.90 /plant) due to high humidity ranging from 64.14 to 86.14 per cent during 1999-2000 while negligible (0.00 to 3.30 /plant) in next season. The jassid population ranged from 2.00 to 11.05 and 1.80 to 11.40 /plant during 1999-2000 and 2000-2001, respectively. The highest whitefly population (4.35 /plant) was recorded in 14^{th} and 18^{th} Meteorological Week in first season whereas in 10^{th} and 11^{th} MW in next season (2.70 /plant). They further observed that aphid population showed significant positive correlation with maximum temperature during both years (r = 0.966 and 0.891, respectively). Jassid population showed significant positive correlation between maximum and minimum temperature (r = 0.953 and 0.988, respectively) during first year and significant with maximum temperature (r = 0.879) and significantly negative (r = -0.657) with AM (Ante meridian) humidity during next season. Further they reported significant positive association between whitefly population and maximum temperature (r = 0.958 and 0.905) during 1999-2000 and 2000-2001, respectively and significantly negative correlation (r = -0.666) between relative humidity (AM) and whitefly during 2000-2001.

2.1.2. Population dynamics of *E.vittella*

In Maharashtra, Mote (1977) reported presence of *E. vittella* on okra after six weeks of the germination in *kharif* and summer seasons. The pest intensity in summer rapidly increased and reached to its peak (69.91 per cent) in 9^{th} week after germination while in *kharif* it gradually increased upto 10^{th} week after germination. From 11^{th} and 10^{th} weeks, the pest incidence declined suddenly in *kharif* and summer season, respectively.

Radke and Undirwade (1981) noticed the mean maximum, minimum and average temperature (29.4°C, 12.2°C and 20.8°C; respectively) with an average relative humidity of 53.2 per cent during severe attack of *E. vittella* on okra.

Kashyap and Verma (1982) observed that the population of *E. vittella* and percentage of infested fruits were not correlated with the prevailing temperature, relative humidity or rainfall since the pest population tend to concentrate on few preferred fruits. The incidence generally occurred after rainfall.

Dhawan and Sidhu (1984) reported that maximum damage was caused due to *Earias spp.* to okra fruits (67.7 per cent) and buds (52.4 per cent) in late October. The maximum damage to shoots (1.7 per cent) and flowers (1.5 per cent) occurred in mid August. In the spring crop, the maximum damage to fruit (32.04 per cent) and larval population (1.4 plant^{-1}) were observed in late July. The population of *Earias spp.* increased slowly upto mid-September and rapidly thereafter. Heavy rainfall adversely affected population build-up of *E. vittella*, *E. insulana* and *E. curpreoviridis*.

Dhamdhere *et al.* (1985) found that shoot and fruit infestation by the pest ranged from 5.5 to 23.9 and 25.93 to 40.91 per cent in *kharif* and summer, respectively during 1980 and 4.65 to 17.15 and 1.75 to 16.62 per cent during 1981. Temperature and humidity had no apparent effect on the pest activity in 1980, but in 1981 humidity had positive effect.

Kumar and Urs (1988) reported that infestation on okra was higher in warmer months than in rainy or cooler months. There was a significant positive correlation of the pest population with temperature and negative correlation with relative humidity. The rainfall did not show any correlation with the pest population.

Kadam and Khaire (1995) reported that there was significant and negative correlation of pest population with RH (> 60 per cent) and rainfall (> 20 mm per week). The pest infestation could be reduced to a greater extent by growing okra during rainy seasons.

Pawar *et al.* (1996) reported that there was significant negative correlation of pest population with relative humidity, rainfall and wind velocity. The crop sown on 15[th] May and 1[st] June had a lower incidence (17.9 to 18.6 per cent) of fruit borer.

Field surveys of okra conducted during the summer of 1993 and 1994 in Madhya Pradesh indicated initiation of shoot damage in two to three week old plants, which reached a peak (8.5 per cent of shoot damage) before fruiting. Fruit infestation started at the beginning of fruiting, and reached a peak (41.25 per cent) before harvesting in the first fortnight of June. Mean maximum temperature (^{O}C) and percentage fruit damage were significantly correlated in both the years with regression equations of Y = -99.46 + 3.121 x (1993) and Y = -62.54 + 2.216 x (1994) (Y = fruit damage and x =temperature) (Shukla *et al.*, 1997).

Gupta *et al.* (1998a) correlated percentage fruit infestation of okra on weight basis with weather factors. Percentage infestation was positively correlated with minimum temperature (r = 0.82), morning relative humidity (r = 0.79), evening relative humidity (r = 0.88) and total rainfall (r = 0.34), and negatively correlated with maximum temperature (r = -0.6794). Multiple regression analysis revealed that increase in relative humidity in the afternoon by a unit would result in increase of 0.595 per cent fruit infestation. Furthermore with one unit increase in precipitation, there was 0.154 per cent decrease in the fruit infestation.

Zala *et al.* (1999) reported the borer initiation on okra (Cv. Parbhani kranti) in Gujrat from three and four weeks old crop upto removal of crop. Bright sunshine hours and maximum and moderate temperature showed significant positive, whereas mean vapour pressure and relative humidity showed significant negative influence on larval activity.

Patel and Patel (2000) found that the infestation of *E. vittella* on bud and boll started from 8 and 11 weeks of age of the cotton crop. The oviposition behaviour of spotted bollworm showed positive correlationship with wind speed and relative humidity (morning, evening and mean) whereas, larval activity had positive association with the rainfall as well as evening relative humidity.

2.2. Bioefficacy of insecticides against pests of okra

2.2.1 Bioefficacy of imidacloprid, thiamethoxam and carbofuran

Palaniswamy (1971) and Gaikwad and Pawar (1979) tested various systemic insecticides and found aldicarb 10 G and carbofuran 3 G as most effective in controlling aphid and jassid population.

Krishnaiah *et al.* (1976) evaluated 26 insecticides for control of major pests of okra. They found that carbofuran 5 per cent seed treatment protected the crop from the attack of jassids till the initiation of fruit set.

Kadam (1978) found that disulfoton 7 per cent and carbofuran 7 per cent were the most effective insecticides against jassids.

Mohan *et al.* (1983) reported that the number of *A. devastans* were kept low for three weeks by seed treatment with a flowable paste formulation of carbofuran before sowing and foliar spray of methamidophos or monocrotophos at 0.5 kg a.i./ha or fenvalerate at 0.2 kg a.i./ha.

Raghunath *et al.* (1987) reported that the application of phorate and carbofuran at 0.5 and 1 kg a.i./ha, respectively along with seed followed by the need based applications of carbaryl 0.2 per cent or malathion 0.1 per cent or quinalphos 0.05 per cent were effective in controlling the major pests of okra.

Kumar *et al.* (1989) reported that application of carbofuran 3G at 1 kg a.i. /ha at the time of sowing did not give effective control of *A. biguttulla biguttulla* and *A. gossypii* at the later crop stages.

Mote *et al.* (1994) used imidacloprid 70 WS as seed dresser on okra at 5, 7.5, 10 and 15 g/kg seed for control of sucking pests and reported that imidacloprid 15 g /kg seed treatment was found promising against sucking pests of okra *viz.*, aphids, jassids, thrips, mites and whiteflies, also observed least per cent of Y.V.M. affected plants and obtained higher yield in these treatments.

Wang *et al.* (1995) conducted tests on efficacy and toxicity of the newly developed insecticide imidacloprid in cotton aphid control in the laboratory in Nanjing and in the field at Siyang in Jiangsa Provnice and at Taiynan in Shanxi Province, China during 1993-94. Tests on aphids on potted cotton in the laboratory treated with 0.63 mg /kg imidacloprid liquid showed that 5 days later, the control was above 95 per cent. In the field cotton aphids were controlled with imidacloprid 37.5 g/ha. After five days, control was above 95 per cent. After 7-10 days control was still above 90 per cent.

Sharma *et al.*, (1995) reported that in a field experiment in 1992 at Phaltan, Maharashtra, Cotton cv. NH-101 was treated with 10, 15 or 20 kg/ha of controlled release carbofuran formulations Furadan 3 GC III or Furadan 3 GV IV. The dominant pests were *A. gossypii, A. biguttulla biguttulla, Helicoverpa armigera, E. insulana* and *Pectinophora gossypiella*. Treatment with 20 kg Furadan 3 GV IV produced the highest seed cotton yield. Treatment with 20 kg Furadan 3 GC III was the most effective for the control of *A. gossypii*.

Kumar *et al.* (1996) tested carbofuran 3 G, phorate 10 G, carbosulfan 25 STD and carbofuran 25 EC at 150, 300 and 450 g a.i./ha as seed treatment and malathion 50 EC and carbaryl 50 WP @ 400-500 ml/acre as foliar and reported that all the insecticides, irrespective of seed treatment or foliar sprays increased the fruit yield significantly.

Murthy *et al.* (1996) conducted a field experiment during 1995 in India to investigate the best insecticide management strategy to control *bhendi* fruit borer (*E. vittella* and *E. insulana*) incidence. The management strategy that included seed treatment with carbofuran 3 G (10 g a.i. /kg) and mancozeb 75 WP (3 g a.i./kg) + application of 5 per cent oil soaked urea (25 kg/ha) at 30 and 50 DAS resulted in an extra marketable yield of 1.5 q/ha and therefore was concluded to be the best.

Singh *et al.* (1996) tested imidacloprid (Gaucho 70) as a seed treatment for the protection of cotton against *A. biguttulla biguttulla* (*A. devastans*) in Punjab, at rates of 5, 7.5 and 10 g / kg seed and reported that all rates were equally effective against the pest upto 121 days. Imidacloprid also provided effective control of termites, but some phytotoxicity was observed.

Sreelatha and Divakar (1997) reported that seed treatment with imidacloprid 7.5 g /kg of okra seed effectively controlled aphids and jassids and also increased the plant height, leaf area and yield of okra. The seed treatment also contributed in avoiding two foliar sprays during the vegetative stage of the crop.

Patel *et al.* (1997) reported that soil application of carbofuran at 0.5 kg a.i./ha or phorate at 0.7 kg a.i./ha 15 days after transplanting alone failed to check the population of chilli thrips (*Scirtothrips dorsalis*) effectively.

Senn *et al.* (1998) in their laboratory studies and field trails indicated that dose rates of thiamethoxam between 10 and 200 g a.i. /ha applied as foliar /seed treatment, were sufficient for controlling all target pests such as aphids, whiteflies and thrips on cotton.

Gul (1998) screened five insecticides against *A. bigutttulla biguttulla* on okra and found that imidacloprid 200 SL was the most effective in controlling jassids over a longer period.

Gupta *et al.* (1998b) reported that seed treatment with imidacloprid 0.5 per cent w/w followed by five sprays at 15 days intervals with synthetic insecticides (monocrotophos 500 g a.i. /ha, deltamethrin 12.5 g a.i./ha, endosulfan 750 g a.i./ha, cypermethrin 60 g a.i./ha, triazophos 600 g a.i./ha) were effective in controlling cotton pests and increasing seed cotton yield.

Gupta *et al.* (1998c) conducted field studies in New Delhi, to determine the efficacy of imidacloprid for the control of jassids (Cicadelllidae) and whitefly (Aleurodidae) on cotton. The insecticide was applied as a foliar application (0.005 and 0.02 per cent) and seed treatment (3 and 5 g/kg seed). The seed treatment controlled cicadellids for 61-76 days. Further they reported that overall, imidacloprid was very effective against cicadellids, even at 3 g/kg (seed treatment) and 0.005 per cent (foliar application) and protected the crop until the initiation of spraying against bollworms.

Katyare (1999) found that for spray treatments though initially at higher doses, *i.e.* 0.0075 and 0.01 per cent of imidacloprid and thiamethoxam were highly effective; considering efficacy, persistence and economy, lower dose of imidacloprid and thiamethoxam at 0.5 per cent seed dressing and 0.00125 per cent spray were effective in checking aphid, jassid population and in governing plant growth characters and yield.

Effects of seed treatment with thiamethoxam and fipronil were evaluated by DePorft *et al.* (1999) in Belgium in several crops including sugarbeet, maize and cereals. Efficacy of both the compounds was found to be at par with imidacloprid.

Scott *et al.* (2000) studied the experimental insecticides, Regent® (fipronil), Actara® (thiamethoxam) and Steward® (indoxacarb) for the control of tarnished plant bug (*Lygus lineolaris*) on cotton. Results indicated that best results were obtained by treatment with all three compounds and bug control was as good as or better than the standard treatments (lambda-cyhalothrin, methamidophos, oxamyl, acephate and cyfluthrin).

Vadodaria *et al.* (2001b) stated that seed treatment with thiamethoxam at 4.3 and 2.8 g/kg seed, imidacloprid 600 FS at 12 and 9 ml/kg, and imidacloprid 70WS at 7.5 g/kg kept the population of aphids, jassids and thrips below economic threshold level on cotton upto 50, 60 and 30 days after germination, respectively. Thiamethoxam enhanced the growth of cotton plants besides controlling sucking pests.

Insecticide assessment test comprising of three insecticides *viz.*, imidacloprid (Gaucho®), thiamethoxam (Adage®) and fipronil (Regent®) as seed treatment against insect pests of winter wheat were undertaken by Wilde *et al.* (2001). Imidacloprid and thiamethoxam were efficacious against early season infestations of greenbug (*Schizaphis graminum*) and the Russian wheat aphid (*Diuraphis noxia*) at all tested rates. All these insecticides effectively controlled autumn infestation of Hessian fly (*Mayetiola destructor).*

Krishna Kumar *et al.* (2001) evaluated efficacy of imidacloprid and thiamethoxam on okra variety Arka Anamika. Results indicated that thiamethoxam 25 WG was on par with imidacloprid (Gaucho 600 FS) seed treatment @ 12 ml/kg of seed in reducing the leafhopper infestation. Lower concentration of imidacloprid seed treatment was less effective.

Dhawan and Simwat (2002) evaluated thiamethoxam (Actara 25 WG), a new molecule of nitroguanidine group at 25.0, 37.5, 50.0 and 62.5 g a.i./ha along with imidacloprid (Confidor 200 SL) @ 20 g and oxydemeton methyl (Metasystox 25 EC) @ 188 g a.i./ha for the control of cotton jassid infesting upland cotton, *Gossypium hirsutum* during 1998 and 1999 crop season in five multilocation trials and found that thiamethoxam @ 25 g a.i. /ha was significantly better than oxydemeton methyl and was at par with imidacloprid for the control of cotton jassid.

Seed treatment with imidacloprid 70 WS @ 0.2, 0.3 and 0.5 per cent, thiamethoxam @ 0.2, 0.3 and 0.5 per cent and untreated control as 7 treatments, replicated thrice in R.B.D. were field evaluated for their efficacy against sucking pests of green gram, var. TARM-18, at Rahuri during *kharif* season of 1999. Though all the dosages of imidacloprid and thiamethoxam were found effective in controlling sucking pests, the treatments with 0.5 per cent concentration were most effective. Aphids and jassids were controlled effectively, while there was little effect on thrips and no effect on mites was observed by any of these insecticides. When two chemicals were compared with each other, thiamethoxam (70 WS) was found to be superior to imidacloprid (70 WS) in all respects (Nakat *et al.*, 2002).

Kalra *et al.* (2001) reported that thiamethoxam was 454 times more toxic than malathion to *A. biguttulla biguttulla*. They further reported that imidacloprid gave more than 80 per cent mortality of this pest at 4 times lower the normal concentration (0.000225 per cent) while there was development of resistance in leafhopper to the commonly recommended insecticides.

Patil *et al.* (2002) evaluated imidcalcoprid 17.8 % SL for its relative efficacy against sucking pest complex of chilli *viz.* aphids, jassids and thrips in comparison with conventional insecticide during *kharif* 2002 season and reported that imidacloprid @ 125 and 150 ml/ha were highly effective against the important sucking pest complex of chilli and proved to be better than monocrotophos and dimethoate.

Katole *et al.* (2003) reported that seed treatment of sorghum with imidacloprid 70 WS @ 15 g /kg or thiamethoxam 70 WS @ 10 g /kg followed by foliar sprays after 30 days with imidacloprid 17.8 SL @ 0.01 per cent or thiamethoxam 25 WG @ 0.01 per cent were highly effective for the management of shootfly and stem borer.

Nagangoud *et al.* (2003) showed that thiamethoxam (Actara 25 WG) at 0.75 and 1.0 g/l was more effective than the commonly used insecticides like carbaryl and moncrotophos resulting in cent per cent mortality of mango hoppers.

2.2.2 Efficacy of spinosad, profenophos, cypermethrin and monocrotophos

Effective control of *E. vittella* on okra was obtained with monocrotophos, quinalphos, endosulfan and fenitrothion @ 0.5 and 1.0 kg a.i. /ha by Singh and Kumar (1974) and with monocrotophos 0.40 per cent and phosalone 0.07 per cent by Uthamasamy and Subramanian (1976).

Mote (1978) evaluated 13 insecticides and seed dressers for the control of *A. devastans*, *E. vittella* and *E. insulana* and showed that 2 sprays of 0.03 per cent monocrotophos at an interval of 15 days starting 2 weeks after sowing, followed by three sprays of 0.05 per cent endosulfan at 15 days interval after fruit setting was the best treatment.

Gupta and Dhari (1980) reported that monocrotophos and fenthion were the most effective in checking shoot infestation by *Earias* spp.

Nimbalkar and Ajri (1981) and Babu and Azam (1982) found cypermethrin as most effective against fruit borer of okra.

Sinha and Chakrabarti (1984) concluded on the basis of two years experimentation, by evaluating different synthetic pyrethroids along with some conventional insecticides, that synthetic pyrethroids were invariably more effective for the control of fruit borer on okra.

Jadhav and Navale (1984) found that endosulfan 0.05 per cent and monocrotophos 0.05 per cent applied four times at ten days interval starting from the flowering stage were most effective in reducing the fruit borer infestation on okra.

Pawar *et al.* (1985) reported that permethrin @ 0.015 per cent, cypermethrin @ 0.01 per cent alone or in combination with carbaryl 0.1 per cent, sulphur 0.2 per cent and urea 0.2 per cent were significantly effective over control in reducing the incidence of fruit borer on okra.

Narke and Suryawanshi (1984) reported that cypermethrin 0.0075 per cent and fenvalerate 0.01 per cent were the most effective treatments against *E. vittella*.

Sinha and Chakrabarti (1984) and David and Kumarswami (1991) reported that synthetic pyrethroids were invariably more effective against fruit borer on okra.

Pawar *et al.* (1988) tested 11 insecticides for the control of okra fruit borer and found that a single spray of endosulfan at 500 g a.i./ha, followed by three applications of cypermethrin or fenvalerate at 50 g a.i./ha at an interval of 14 days, were the most effective.

Kakar and Dogra (1988) found that treatment with malathion, monocrotophos and dichlorvos 0.05 per cent were effective in controlling the okra shoot and fruit borer.

Peter and David (1989) reported that in a field trial in Tamil Nadu, cypermethrin (80 g a.i./ha), monocrotophos (300 g a.i./ha) and methomyl (600 g a.i. /ha) controlled *E. vittella* on bhendi.

Sarkar and Nath (1989) found that fenvalerate was the best over decamethrin (deltamethrin), fenvalerate, monocrotophos, phosphamidon, quinalphos, malathion, endosulfan and carbaryl.

Ratnapara and Bharodia (1989) found that lowest infestation of okra shoot and fruit borer was recorded with 0.015 per cent fenvalerate, followed by 0.01 per cent cypermethrin and 0.07 per cent endosulfan and other treatments *viz.*, fluvalinate, carbaryl, acephate, monocrotophos at 0.0075, 0.02, 0.1 and 0.04 per cent concentration, respectively in reducing fruit borer infestation.

Gupta *et al.* (1990) conducted field studies in cotton fields in New Delhi, and reported that two doses of synthetic pyrethroids (fenvalerate, deltamethrin, cypermethrin, flucythrinate, fluvalinate and fenpropathrin) were as effective as a single dose of carbaryl in controlling bollworms (*E. vittella, E. insulana* and *P. gossypiella*). Further there was no significant difference in the level of control obtained with each pyrethroid.

Gupta and Katiyar (1991) controlled *Earias spp.* and *P. gossypiella* with the mixtures of pyrethroid insecticides (deltamethrin or cypermethrin) and monocrotophos without any problem of resurgence of *B. tabaci*.

In field experiment in Maharashtra, India, in 1988-89, okra plants were treated, in each of two applications (at fruit formation and 10 days later), with cypermethrin (12.5 or 15.0 g a.i./ha), fenvalerate (50 g a.i. /ha), cypermethrin (37.5 g a.i. /ha), acephate (375 g a.i. /ha), quinalphos (250 g a.i. /ha) and endosulfan (250 g a.i. /ha). All treatments reduced pod damage caused by *E. vittella*. Cypermethrin treated plants were the least infested (Patil *et al.*, 1991).

Mahala and Jayaswal (1993) reported on the basis of a number of criteria, the most effective of several insecticides tested for the control of bollworms (*P. gossypiella* and *Earias spp.*) on cotton (*G. hirsutum* Linn.) in Haryana, were monocrotophos and quinalphos at 0.75 kg a.i./ha and carbaryl at 1.0 kg a.i./ha.

Prasad *et al.* (1993) reported that alpha-cypermethrin (0.006 per cent), bifenthrin (0.005 per cent) and cypermethrin (0.006 per cent) were effective against *E. vittella*.

Toshniwal (1993) conducted an experiment on mipcin, benfurocarb and triazophos, endosulfan, cypermethrin efficacy and reported that mipcin was effective against sucking pest complex while cypermethrin and endosulfan were effective in reduction of fruit borer infestation.

Sarode and Gabhane (1994) indicated that among 14 treatments, endosulfan 0.06 per cent was the most effective. It was followed by NSKE 5 per cent + ¾ dose of endosulfan (0.045), monocrotophos (0.037 per cent) and NSKE 5 per cent which recorded 14.83, 16.09, 18.13 and 18.16 per cent fruit infestation, respectively and monocrotophos showed a desirable effect against the pest.

Peterson *et al.* (1996) evaluated the use of Tracer (spinosad) in integrated pest management programme for cotton in USA. It was shown that the use of Tracer conserved beneficial arthropods, controlled budworms (*Helicoverpa virescens* Fabricium) and bollworms (*Helicoverpa zea* Boodie) in cotton, reduced square damage, minimized secondary insect pests, increased spray intervals.

Shukla *et al.* (1996) reported that four sprays of fenvalerate 0.05 per cent gave the greatest level of control of okra fruit borer, *E. vittella* and highest healthy fruit yield (7.07 t/ha) followed by cypermethrin 0.005 per cent, malathion 0.05 per cent and Achook 1.0 per cent.

In a field experiment in Rajasthan with okra, Mathur *et al.* (1998) found that combined application of monocrotophos 36 SL (1.0

litre/ha), followed by two sprays of *Bacillus thuringiensis* subsp. Kurstaki (Btk) (Dipel 8 L 1.0 litre /ha) + methomyl 40 SP (0.625 kg/ha) resulted in the lowest fruit damage (4.21 per cent).

Dubey and Ganguli (1998) studied the avoidable losses in okra due to *E. vittella* in Chhattisgarh, and reported that out of 9 treatments tested, phorate 10 G. basal at 1.0 kg a.i./ha + a single spray of monocrotophos at 0.05 per cent + five sprays of cypermethrin at 0.006 per cent resulted in the highest fruit yield (104.23 q/ha).

On the basis of two years study Patil *et al.* (1999) reported that spinosad 48 per cent SC was found promising in controlling bollworms on cotton. Same results were obtained by Dandale *et al.* (2000) who further mentioned that average bollworm infestation in spinosad (75 g a.i. /ha) treated plots was 3.62 per cent when compared with control (14.80 per cent).

A combi-product Sherlone® 29 EC (phosalone 24 per cent + cypermethrin 5 per cent) was screened by Panda *et al.* (1999) against fruit borers of okra, *Earias fabia* and *Helicoverpa armigera* Hubner. The data indicated that Sherlone® 29 EC at 1.75 l/ha proved to be superior to phosalone 2 l/ha, cypermethrin 0.25 l/ha and Spark 1 l/ha in restricting borer infestation.

Peter *et al.* (2000) screened spinosad 2.5 % SC at different use rates against lepidopteran pests of cabbage at NARDI Research Farm, Warangal, Andhra Pradesh. Data revealed that spinosad at 15, 20 or 25 g a.i./ha was better in controlling diamondback moth (*Plutella xylostella* L.), cabbage stem borer (*Hellula undalis* Fabricius) and cabbage leaf webber (*Crocidolomia binotalis* Zeller). Efficacy of spinosad persisted for seven days.

A new insecticide Tracer 48 per cent SC (Spinosad) was compared with traditional insecticides for the control of bollworm (*H. zea*) and tobacco budworm (*H. virescens*) on cotton in Arkansas, USA. Traditional insecticides such as acephate, Curacron and Larvin alone or in combination and Tracer provided acceptable control of the bollworms (Johnson *et al.*, 2000).

Brickle *et al.* (2000) conducted comparison tests with lambda-cyhalothrin, spinosyn, thiodicarb, pyrrole, oxadiazine and avermectin at normal grower rates on cotton bollwrom, *H. zea*. Results revealed that reduced rates of lambda-cyhalothrin, spinosyn and thiodicarb could be used for control of *H. zea* on dryland Bt. cotton.

Decamethrin (0.01 per cent) was the most effective treatment against borer followed by diafenthiuron 0.05 per cent and profenophos 0.05 per cent in okra (Surekha and Arjuna Rao, 2000).

Three years pooled data indicated that spinosad 48 % SC at 75 g a.i./ha and Bulldock 2.5 % SC at 18 g a.i./ha recorded low bollworm population, minimum per cent damage to squares, bolls and locules, and higher seed cotton yields. The lower dose of spinosad (50 g a.i. /ha) was found superior than fenvalerate at 75 g a.i. /ha against bollworms (Vadodariya *et al*, 2001a).

Rao *et al.* (2001) tested commonly used insecticides chlorpyriphos, endosulfan, thiodicarb with new molecules spinosad, indoxacarb and emamectin and reported that the new molecules exhibited very high efficacy against *H. armigera* on cotton.

Srinivasan and Uthamasamy (2001) studied the interaction effect of the chitin synthesis inhibitor with two synthetic insecticides *viz.*, profenophos and alphacypermethrin on spotted bollworm in cotton. The exposure of larvae to conventional insecticides *viz.*, profenophos and alphacypermethrin revealed acute toxicity while diflubenzuron elicited chronic effects.

Sivakumar *et. al.* (2003) tested profenophos alone and in combination with cypermethrin for its field efficacy against selected pests of lady's finger in Tamil Nadu, India and reported that profenphos (Curacron®) @ 2 lit /ha and profenophos + cypermethrin (PolytrinC®) @ 2 lit/ha were found most effective in reducing the damage by shoot and fruit borer, *Earias* spp.

2.3. Effect of different insecticides on marketable fruit yield of okra

Gupta and Dhari (1980) reported that the highest yield increase was provided by monocrotophos followed by carbaryl and chlorpyriphos.

Babu and Azam (1982) noted that the maximum yields were obtained from plots treated with monocrotophos and cypermethrin.

Singh and Singh (1991) reported that spray combinations of endosulfan, malathion, oxydemetonmethyl, dimethoate and monocrotophos (all at 500 g a.i. /ha) with permethrin, and combinations of endosulfan and deltamethrin at 10 g a.i./ha, resulted in effective control of *A. biguttulla biguttulla* and *Earias* spp., and increased the marketable fruit yield.

Patil *et al.* (1991) reported that the cypermethrin treated plants were least infested by *E. vittella* and gave the highest yield.

Toshniwal (1993) noted that cypermethrin and endosulfan were effective in reduction of fruit borer infestation on okra and gave increased yield /ha during season.

Peterson *et al.* (1996) evaluated the use of Tracer (spinosad) in integated pest management programme for cotton in USA and reported that it provided yields equal to current standard programmes.

Gupta *et al.* (1998b) reported that seed treatment with imidacloprid 0.5 per cent w/w followed by five sprays at 15 days interval with synthetic insecticides (monocrotophos 500 g a.i. /ha, deltamethrin 12.5 g a.i./ha, endosulfan 750 g a.i./ha, cypermethrin 60 g a.i./ha, triazophos 600 g a.i./ha) were effective in controlling cotton pests and increasing seed cotton yield.

Mathur *et al.* (1998) reported that the combined application of monocrotophos 36 SL (1.0 liter/ha), followed by two sprays of *B. thuringiensis* subsp. Kurstaki (Btk) (Dipel 8 L 1.0 liter /ha) + methomyl 40 SP (0.625 kg /ha) produced the lowest fruit damage (4.21 per cent) by *E. vittella* on okra and gave the highest fruit yield of 4.07 t/ha.

Dubey and Ganguli (1998) studied the avoidable losses in okra due to *E. vittella* in Chhattisgarh, India and reported that out of nine treatments tested, phorate 10 G basal at 1.0 kg a.i./ha + a single spray of monocrotophos at 0.05 per cent + 5 sprays of cypermethrin at 0.006 per cent resulted in the highest fruit yield (104.23 q/ha).

Panda *et al.* (1999) reported that the use of combi-product Sherlone 29 EC (phosalone 24 % + cypermethrin 5 %) was effective in restricting fruit borer infestation in okra and increasing fruit yield.

Patil *et al.* (2002) reported that the treatment with imidacloprid @ 150 ml/ha was effective against sucking pest complex of chilli and recorded significantly highest yield followed by imidacloprid @ 125 and 100 ml/ha, monocrotophos @ 650 ml/ha and dimethoate @ 750 ml/ha.

Sivakumar *et al.* (2003) tested profenophos alone and in combination with cypermethrin for its field efficacy against selected pests of lady's finger in Tamil Nadu, and reported that profenphos (Curacron®) @ 2 lit /ha and profenophos + cypermethrin (PolytrinC®) @ 2 lit/ha were found most effective in reducing the damage by shoot and fruit borer, *Earias* spp. as well as increasing the yield.

2.4. Economics of various treatment applications in okra pest management

The cost benefit ratio of 1:8.62 was reported by Patel *et al.* (1984) when fenvalerate was tested against okra fruit borer.

Kumar and Srinivasan (1984) reported that the cost benefit ratio was lowest for fenvalerate at 50 g a.i./ha when tested against *E. vittella*.

Rizvi *et al.* (1986) reported endosulfan 0.05 per cent as most effective and profitable control measure for pod borer on pigeon pea.

Joshi (1987) reported that NSKE 5 per cent application in tobacco nurseries against *Spodotera litura* (Fb.) was economical compared to endosulfan, carbaryl and chlorpyriphos.

Fenvalerate 0.02 per cent, cypermethrin 0.02 per cent, monocrotophos 0.04 per cent and dimethoate 0.03 per cent recorded higher net profit of rupees 4490, 4448, 4130 and 3053 /ha, respectively (Pareek *et al.*, 1987).

Kumar *et al.* (1989) reported that the application of monocrotophos 36 EC at 500 g a.i./ha, 21-42 days after germination resulted in the lowest infestation of *A. biguttulla biguttulla* and *A. gossypii* on okra and the highest cost benefit ratio.

Gujar (1992) reported that the application of 5 per cent NSKE against *H. armigera* on pigeonpea were found costlier (1:4.20) compared to endosulfan 0.07 and 0.08 per cent (1:20 and 1:12.1 cost benefit ratio, respectively).

Soon (1992) reported that application of 5 per cent NSKE ranked 3rd with regard to cost benefit ratio next to neem oil 1 per cent and endosulfan 0.07 per cent when applied for insect pest control of agricultural crops.

Murthy *et al.* (1996) reported that the management strategy to control bhendi fruit borer (*E. vittella* and *E. insulana*) which included seed treatment with carbofuran 3G (10 g a.i./kg) and mancozeb 75 WP (3 g a.i. /kg) + application of 5 per cent neem oil soaked urea (25 kg /ha) at 30 and 50 DAS resulted in an extra marketable yield of 1.5 q/ha. This treatment was concluded to be the best with a cost benefit ratio of 1:4.6 and a net yield of 5.9 t/ha.

Shukla *et al.* (1996) reported that fenvalerate 20 EC 0.005 pe cent was highly cost effective for okra protection with a cost benefit ratio c 1:10.3.

Nagare and More (1998) reported that 5 per cent NSKE application in *H. armigera* management on cotton was most economica with highest cost benefit ratio (1:43.32) compared to endosulfan 0.07 pei cent (1:37.74).

2.5. Parasitization of *E. vittella*

Cherian and Kalyasam (1947) observed 60 per cent parasitization by *Rogas aligharensis* (Quadri) on *Earias spp.*

Patel *et al.* (1969) reported *Rogas* near *Rogas pallidator* (Thnd.), *Chelonus helioipae* (Gupta), *Steblymya plebeia* (Mall) as new parasitoids of *Earias* spp. from Gujrat.

Das and Babu (1977) reported *Bracon greeni* Ashm. as an external parasitoid mainly on *Earias* spp.

Sarkate *et al.* (1978) observed that three adults of *Chelonus blackburni* Cam. are sufficient to parasitise 50 larvae of *E. vittella.*

Surulivelu and Menon (1980) reported that ovipoistiion and subsequent development of *C. blackburni* an important egg larval parasitoid of *E. vittella* and other bollworms on cotton was not affected by fenvalerate as it was least toxic to the adult parasitoid.

Swamippan and Balsubramanian (1980) studied potentiality of *C. blackburni* an egg - larval parasitoid of *E. vittella* on cotton and okra at Coimbatore. They recorded 4.5 and 2.8 per cent recovery after field release of the parasitoid on cotton and okra respectively. They further reported that the duration of 19.7 days was required for the life cycle of the parasitoid.

Mahinder and Verma (1981) observed parasitism on cotton bollworms by the parasitoids; *Apanteles angeleti* Musebeck, *Trichogramma chilonis* Ishii, *Bracon greeni* Ashmed and *Rogas* spp. in untreated cotton crop.

Patel and Patel (1981) reported 90 per cent parasitization of *E. vittella* by *R. aligarehensis* in Gujrat under laboratory conditions.

Manoharan and Balasubramanian (1982) reported fenvalerate to be more toxic to the *C. blackburni* than carbaryl, endosufan and monocrotophos.

Patel (1983) found that mixture of methomyl (200 g a.i./ha) + carbaryl (800 g a.i./ha) and parathion (200 g a.i./ha) + carbaryl (800 g a.i./ha) did not show adverse effect on larval parasitoid, *R. aligharensis* on *E. vittella* showing 33.3 per cent parasitism against the 28.6 and 10 per cent parasitism in the case of endosulfan 0.07 per cent and untreated control, respectively.

Manoharan and Balsubramanian (1984) observed that amongst various insecticides tested for their toxicity to *C. blackburni*, phosalone was least toxic to the parasitoid followed by carbaryl, endosulfan, monocrotophos fenvalerate and dimethoate as evident from the LC_{50} values of 1.34, 0.7702, 0.4802, 0.04062, 0.03166 and 0.01062 per cent estimated for the insecticides, respectively.

Naganagoud and Thontadarya (1984) observed 0.7 and 3.8 per cent parasitism in *E. vittella* by *Rogas* spp. in the months of November and December, respectively.

Patel and Bilapate (1984) studied the field life tables and key mortality factors and reported that *E. vittella* passed through five generations and the parasitization was 9.25, 22.22, 21.43, 35.47 amd 22.23 per cent by *R. aligharensis* and 14.2, 19.51, 21.42, 16.66 and 23.08 per cent by *Bracon* spp. on cotton.

Bilapate (1985) reported four overlapping generations of *E. vittella* on cotton in pesticide free plots in Marathwada region during Aug., 1982 to Jan., 1983. Parasitization by *R. aligharensis* (59.07 per cent in the first generation) was one of the important mortality factors in the larval stage. Parasitization by *Macrochelonus* spp. (*Chelonus spp.*), *Bracon spp.* and *Chalcis* spp. in the first generation averaged 7.55, 5.10 and 3.23 per cent respectively. Similar results were presented for the other generations.

Hegde *et al.* (1987) reported that permethrin (125, 150, 200 ppm) was less toxic to parasitoid, *R. aligharensis* than cypermethrin (50 and 100 ppm), monocrotophos (100 ppm) and endosulfan (1000 ppm) tested under field conditions in 1978-80.

Verma and Shenhmar (1988) studied eggs, larvae and pupae of the gelechid *P. gossypiella* and the noctuid *Earias* spp. collected from cotton field in Punjab, in 1980-85 to determine the indigenous natural enemies that may be suitable for the biological integrated control of these pests as well as their period of greater activity and percentage parasitism.

The host stages were reared in the laboratory at 26-27°C and 65.70 per cent RH. The results indicated that the braconids *R. aligharensis and Apanteles angaleti* (Muesebeck) resulted in 33 and 20-25 per cent parasitism in August - December and January - December, respectively.

Somasundaram and Raghupathy (1988) found that fluvalinate was least toxic to *C. blackburni* followed by deltamethrin and endosulfan.

Eggs of *Corcyra cephalonica* Stainton infected with *C. blackburni* were sprayed in the laboratory with insecticides. The order of toxicity to the parasitoid was: triazophos > deltamethrin > endosulfan > dimethoate > cypermethrin > lambda - cyhalothrin > monocrotophos > fenvalerate > flucythrinate > carbaryl > fenpropathrin > phosalone (Paul and Srivastava, 1989).

Sathe and Ingawale (1995) reported *Apanteles shrii,* a new species of *Apanteles,* which parasitizes *E. vittella.*

Latha *et al.* (1998) evaluated six insecticides, endosulfan, chlorpyriphos, quinalphos, carbaryl, cypermethrin and fenvalerate for their effects on *C. blackburni.* Initial toxicity, development of *C. blackburni* when exposed to the insecticides and the persistence of the insecticides were studied. All 6 insecticides killed 100 per cent of the adults within 24 h of exposure. Endosulfan was found to be safest, with the highest parasitoid emergence both from insecticide- treated *C. cephalonica* eggs, which were subsequently parasitised and from parasitized eggs treated with insecticides.

2.6. Crop loss assessment due to key pests

Srinivasan and Gowder (1960) reported 40 to 50 per cent damage to okra fruits due to shoot and fruit borer.

Rawat and Sahu (1973) carried out field tests to estimate losses in growth and yield of okra caused by *Amrasca* (*Empoasca*) *devastans* Dist. and *Earias* sp. In one set of plots, the pests were controlled by the application of granules containing 5 per cent dimethoate at a rate of 20 kg/ha below the seed in the furrow followed by two sprays of 0.02 per cent endrin and six sprays of 0.2 per cent carbaryl at 10 days interval starting 5 weeks after sowing. Another set was left untreated. Average losses recorded in plant height, the number of leaves per plant and the weight of healthy fruits were 49.8, 45.1 and 69 per cent, respectively.

Mote (1977) reported 17.31 to 37.11 and 20.69 to 69.91 per cent infestation of *bhendi* fruit borer on okra in rainy (*Kharif*) and summer seasons, respectively.

Singh and Chopra (1979) reported that the per cent reduction in the average plant height, average number of leaves /plant, average number of total fruit (s) /5 plants, average weight of total fruit (s) / 5 plants and average weight of healthy fruit (s)/ 5 plants in control plots in comparison with malathion and leptophos treated plots were 18.30, 28.57, 27.61, 27.00, 40.65 and 37.58 and 21.62, 28.57, 30.27, 29.67, 44.89 and 43.24, respectively.

Rao (1980) conducted studies on crop loss due to insect pests of okra by differential protection, by using two insecticides *viz*., formothion (against sucking insects) and carbaryl (against fruit borer) and observed that fruit borers inflicted greater losses (33.10 to 45.03 per cent by number and 21.11 to 39.26 per cent by weight with 5.40 to 13.24 q/ha reduction in yield) as compared to sucking insects (1.5 per cent by number and 3.76 per cent by weight with 7.2 q/ha reduction in yield).

Krishnaiah (1980) reported that losses in okra due to leafhopper (*A. biguttulla biguttulla*) and fruit borer (*E. vittella*) were 40-56 and 49-74 per cent, respectively.

Radke and Undirwade (1981) recorded 88.33 to 100 per cent infestation of *E. vittella* on okra during December 1977 and January 1978.

Srinivasan and Krishnakumar (1983) conducted field trials for assessment of losses caused by sucking pests and fruit borer in okra. They observed that the percentage yield losses following the treatments with carbaryl (4.2 per cent), carbofuran + phosalone (4.1 per cent) and disulfoton + carbaryl (2.9 per cent) were lowest and were not significantly different from one another. The same treatments produced maximum marketable yields. The loss caused in the unprotected control plots was 13.5 per cent and this was on par with losses resulting from the application of carbofuran followed by disulfoton. The application of granular insecticides to control sucking pests without controlling fruit borer did not significantly increase marketable yields. Of the total yield, 19 per cent was lost to jassids and aphids and 45 per cent was lost to the fruit borer.

Jadhav and Navale (1984) registered 48.25 per cent loss in the fruit yield due to the fruit borer on okra.

The fruit damage to the tune of 12.36 per cent by the pest on okra fruits was recorded during the rainy (*Kharif*) season by Narke and Suryawanshi (1984).

Dhandapani (1985) estimated 9.6, 3.20, 27.73, 7.16 and 16.27 per cent loss in yield of okra cultivars CO-1, AE77, AE113, AE180 and Pusa Sawani, respectively. The yield loss in different cultivars of okra was attributed to their variability in susceptibility to fruit borer, *E. vittella*.

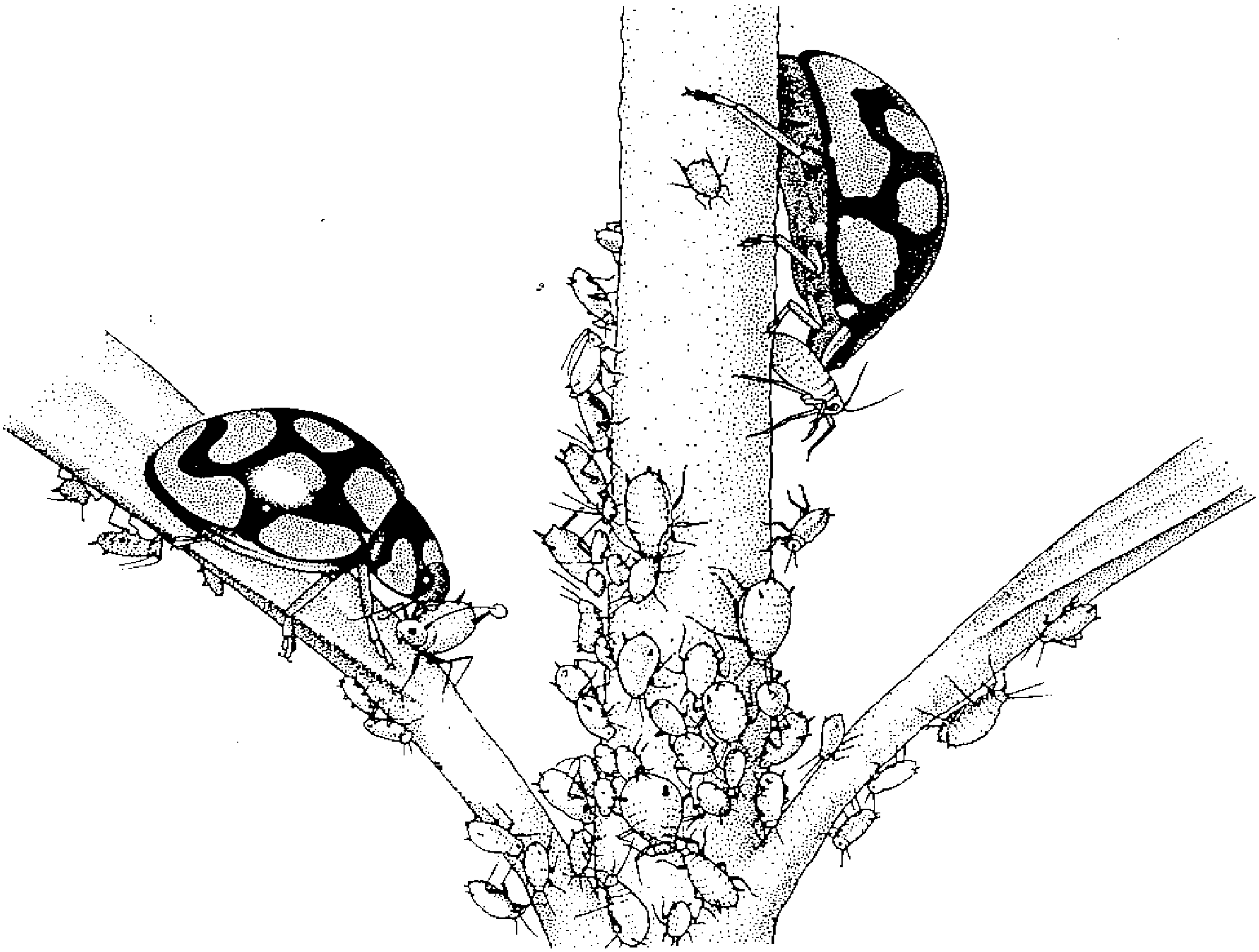
Choudhary and Dadheech (1989) estimated that if insecticidal protection was not given, there would be a net yield loss of 54.04 per cent.

Samuthiravelu and David (1990) reported a yield loss of 121.33 kg/ha due to *E. vittella* on cotton.

Brar *et al.* (1994) observed that the loss in fruit yield of okra by *Earias* spp. was lowest (22.79 per cent) in crop sown on July 30 and maximum (50.58 per cent) in crop sown on May 30.

Dubey and Ganguli (1998) studied avoidable losses in okra due to *E. vittella* in the Chhattisgarh, during the summer of 1996 and reported that of 9 treatments tested, phorate 10 G basal at 1.0 kg a.i./ha + a single spray of monocrotophos at 0.05 per cent + 4 sprays of cypermethrin at 0.006 per cent resulted in the highest marketable fruit yield (104.23 q/ha), followed by phorate 10 G basal followed by 7 sprays of monocrotophos.

Suryawanshi *et al.* (2003) reported that the per cent avoidable losses caused by major insect pest of okra in plant height, leaf number/plant, fruit number/plant and marketable fruit yield in unprotected plots were 43.23, 10.77, 27.73 and 58.87 per cent, respectively. They further mentioned that maximum yield was obtained with four sprays of monocrotophos 0.04 per cent on 15-74 days old crop, thereafter yields were not significant.



MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present investigations were undertaken with a view to study the impact of weather parameters on the population build-up of key pests of okra. The study was also aimed to evaluate the bioefficacy of certain newer systemic insecticides as seed dressers against sucking pests of okra i.e. aphids (*Aphis gossypii* Glover); jassids (*Amrasca biguttulla biguttulla* Ishida) and whiteflies (*Bemisia tabaci* Gennadius). The efficacy of different insecticides as sprays against okra shoot and fruit borer (*Earias vittella* Fabricius) . was also evaluated. The laboratory experiment was conducted to study the effect of different insecticidal treatments on the parasitization of *E. vittella* A separate field experiment was conducted for the assessment of crop losses due to key pests during various growth periods of okra.

The materials used and methods adopted during the present investigations are given below.

3.1. Population dynamics of key pests of okra

3.1.1. Experimental site

Field experiment was conducted during the summer seasons of 2000-2001 and 2001-2002 at (the farm of Department of Agril. Entomology) M.A.U., Parbhani to study the population dynamics of key pests of okra. Parbhani Kranti variety of okra was grown over an area of 10 x 10 m^2. The field was divided into four quadrates of 5 x 5 m^2 size. The spacing followed was 30 x 30 cm. No plant protection measures were taken up for the pest control. The common agronomic practices were followed to raise a good crop.

3.1.2. Methods of recording observations

Observations were recorded on population of sucking pests from seven days after germination till the harvest at seven days interval on 20 randomly selected plants (5 plants from each plot). The sucking pests count was taken from 3 leaves per plant, one each from top, middle and bottom canopy of the plant as per Singh and Kaushik, 1990.

Observations on infestation of okra fruits caused by shoot and fruit borer, *E. vittella* were recorded at the time of each picking. For this, the infested and healthy fruits from each plot were weighed separately and per cent fruit infestation was worked out.

The data on prevailing temperature, relative humidity, rainfall and bright sunshine hours during the course of investigation were recorded from the Meteorological Observatory, M.A.U., Parbhani.

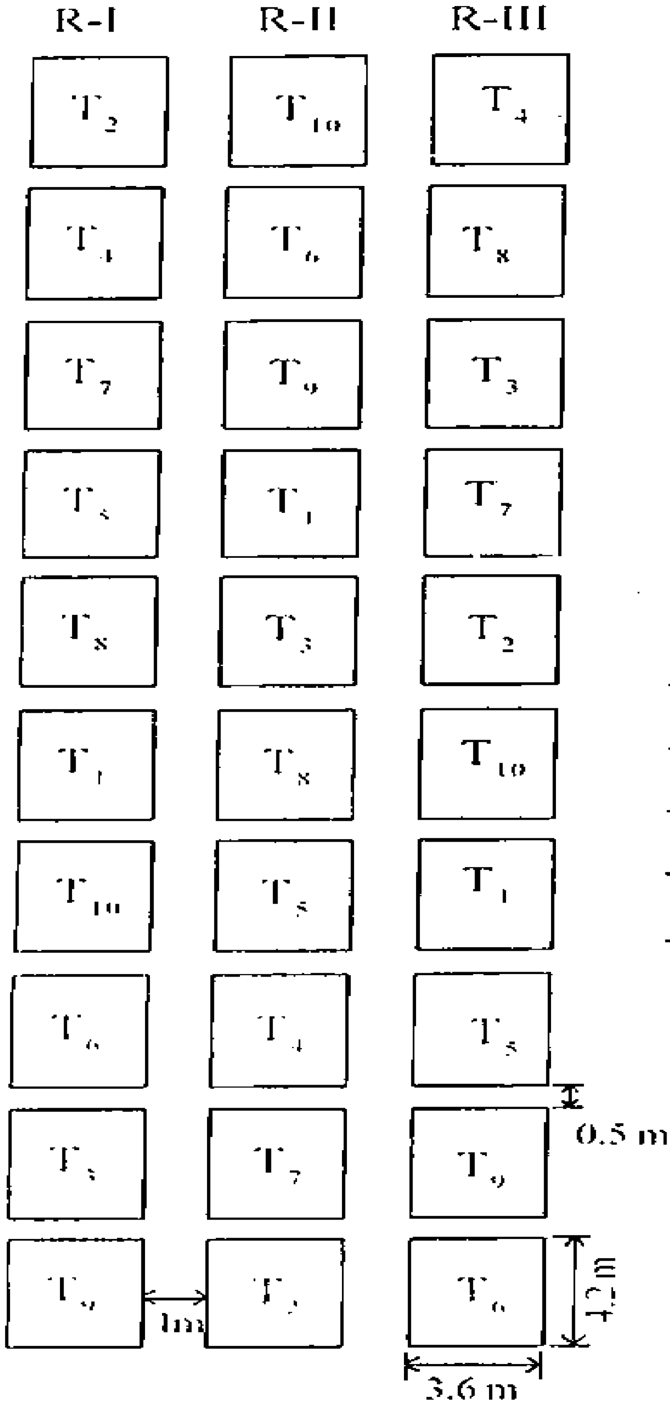
3.1.3. Statistical analysis

The data on population of sucking pests were subjected to Poisson value conversion ($\sqrt{x + 0.5}$, where 'x' is the number of individual insect pest) and statistically analysed. Whereas data on percentage fruit damage were transformed to angular values and subjected to statistical analysis in RBD. Data thus obtained in two years i.e. during 2000-2001 and 2001-2002 were pooled and presented in Table 1 and 3. Correlation between incidence of insect-pests and important weather parameters was also worked out as per Panse and Sukhatme, (1967) and results are presented in Table 2, 4 and 5.

3.2. Efficacy of certain newer insecticides against key pests of okra

3.2.1. Experimental site

The experiments were conducted during the summer seasons of 2000-2001 and 2001-2002 at the farm of Dept. of Agril. Entomology,



N

Treatment Details

T_1 - Imidacloprid @ 10 g a.i./kg seed treatment fol lowed by spinosad 48 SC @ 750 ml/ha.

T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha

T_3 - Imidacloprid @10 g a.i./kg seed treatment fol lowed by monocrotophos 36 SL @ 750 ml/ha.

T_4- Thiamethoxam @ 4 g a.i./kg seed treatment fol lowed by spinosad 48 SC @ 750 ml/ha.

T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha

T_6- Thiamethoxam @ 4 g a.i./kg seed treatment fol lowed by monocrotophos 36 SL @ 750 ml/ha.

T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.

T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha

T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.

T_{10}- Untreated control

Fig.1. Layout of bioefficacy experiment

M.A.U., Parbhani. The site was uniform with typical black cotton soil, having high fertility and fairly good drainage.

3.2.2. Experimental design

The experiment was laid out in a randomized block design with 10 treatments replicated thrice. The gross plot size was 3.6 x 4.2 m with 12 rows and 14 dibbles in each row. The spacing followed was 30 x 30 cm. The fertilizer dose applied was 100:50:50 kg NPK /ha. The distance between two adjacent plots was 0.5 m whereas 1 m between the replications. The plan of layout is presented in Fig. 1.

3.2.3. Sowing

Dibbling of okra var. Parbhani Kranti was done on 24th of February during 1st year of research and on 26th of February during second year of investigations. Three seeds per hill were sown. After thinning, only two healthy plants per hill were maintained.

3.2.4. Details of insecticides

In the present investigation three insecticides were evaluated as seed dressers against the sucking pests (aphids, jassids and whiteflies) alternated with three insecticides as sprays against the okra shoot and fruit borer, *E. vittella.* Thus total nine combinations of seed dressers and spray insecticides were evaluated. The details of the insecticides used are given below.

3.2.4.1. Imidacloprid

It is the first generation neonicotinoid insecticide introduced by Bayer in 1991. It is a neurotoxin and acts by binding the nicotinic acetylcholine receptor (Abbink, 1991). This chemical possesses plant systemic properties and is effective at low concentrations against a spectrum of sucking insects (Elbert *et al.*, 1991) and at higher concentrations against various chewing insects.

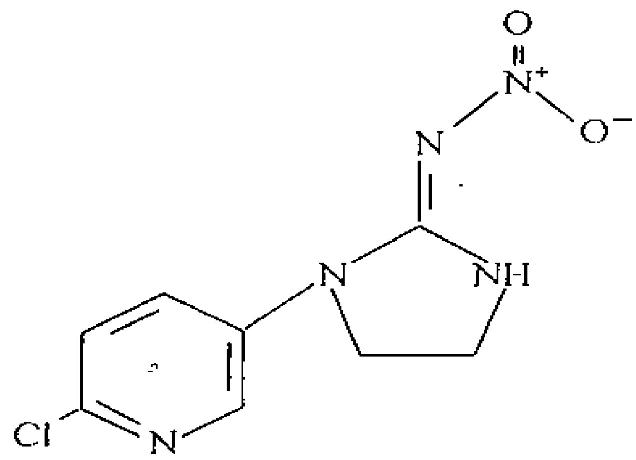
A : Nymph and adult of *Aphis gossypii*

B : Adult of *Amrasca biguttulla biguttulla*

C : Adult of *Bemisia tabaci*

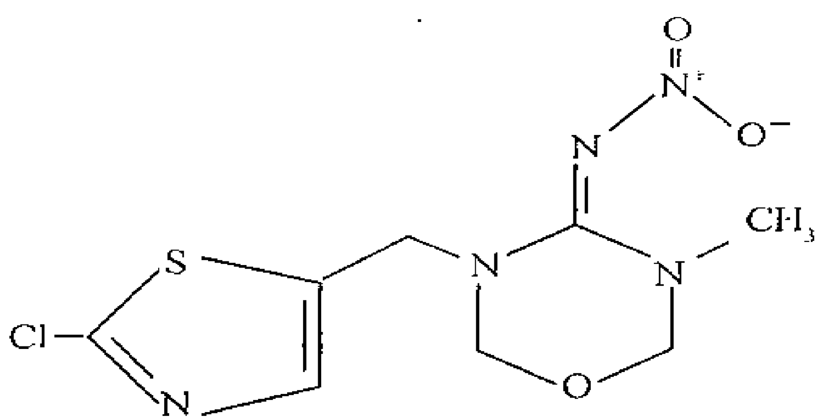
Plate : 1

Imidacloprid
$C_9H_{10}ClN_5O_2$



Chemical name-
1[(6-chloro-3-pyridinyl)-methyl]-4,5-dihydro-N-Nitro-1H-imidazol-2-amine.

Thiamethoxam
$C_8H_{10}Cl\,N_5O_3\,S$



Chemical name-
3-(2-chloro-thiazol-5-ylmethyl)-5-methyl-[1,3,5] oxadiazinan-4 ylidene-N-nitroamine.

Fig. 2. Chemical formula and structure of
A. Imidacloprid
B. Thiamethoxam

Technical name	-	Imidacloprid
Trade name	-	Gaucho®
Dose used	-	10 g a.i./kg seed
Chemical name	-	1[(6-chloro-3-pyridinyl)-methyl]-4,5-dihydro-N-Nitro-1H-imidazol-2-amine.
Chemical formula and structure	-	Given in Fig. 2A.
Chemical class	-	Neonicotinoid
Chemical subclass	-	Chloronicotinyl compound (*first generation*)
Source	-	Bayer India Limited.

3.2.4.2. Thiamethoxam

It is a second-generation neonicotinoid compound. Thiamethoxam interacts with receptor protein of nicotinic acetylcholine receptors in the nerve fibre membrane. It is a new systemic, broad-spectrum insecticide for foliar use and seed treatment and has contact and stomach activity also. Following foliar application, the activity is excellent against sucking pests and moderate against chewing pests in general. It also shows excellent activity against soil insects.

Technical name	-	Thiamethoxam
Trade name	-	Cruiser ®
Dose used	-	4 g a.i./kg seed
Chemical name	-	3-(2-chloro-thiazol-5-ylmethyl)-5-methyl-[1,3,5] oxadiazinan-4 ylidene-N-nitroamine.
Chemical formula and structure	-	Given in Fig. 2B.
Chemical class	-	Neonicotinoid
Chemical subclass	-	Thianicotinyl compound (*Second generation*)
Source	-	Novartis (Syngenta) India Ltd, Mumbai.

3.2.4.3. Carbofuran

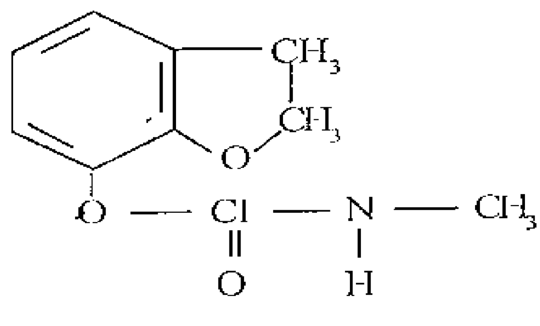
It is a plant systemic broad-spectrum insecticide of carbamate group and effective against sucking pests. Also acts as miticide and nematicide. It is a crystalline solid having slight phenolic odour. It has a poor solubility in water and a little better solubility in organic solvents.

Technical name	-	Carbofuran
Trade name	-	Furadan® 3G
Dose used	-	5 % seed treatment
Chemical name	-	2,3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate.
Chemical formula and structure	-	Given in Fig. 2C.
Chemical class	-	Carbamate
Chemical subclass	-	Phenyl carbamate
Source	-	M/s Rallis India Limited., Mumbai.

3.2.4.4. Spinosad

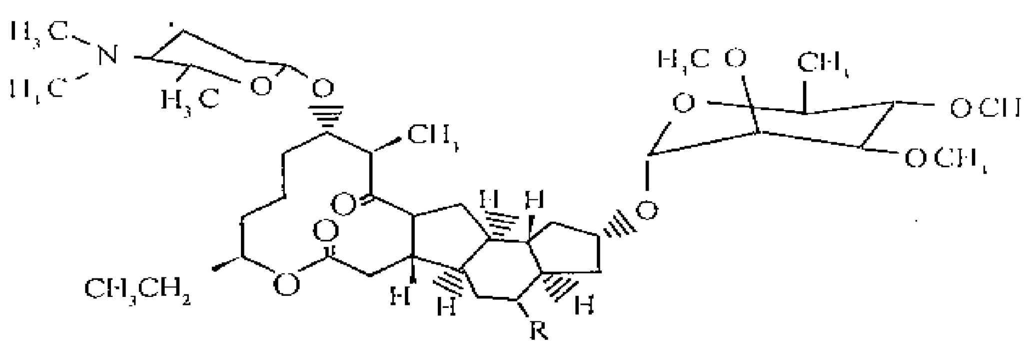
The spinosyns are a new family of macrolide pest control agents that are active against several classes of insects, especially lepidopterous pests. A total of 23 spinosyns has been isolated so far (Mertz and Yao, 1990). Spinosad is a name given to a mixture of spinosyn A (65-95 per cent) and spinosyn D (5-35 per cent), the active metabolite produced during fermentation of a rare naturally occurring soil bacterium, *Saccharopolyspora spinosa* sp.nov. This newly discovered species belongs to the order of Actinomycetales, a bacterium that exhibits fungal structure characteristics. Spinosad is selective and spares the key beneficials and pollinators and is environmentally safer due to low persistence (Miles and Dutton, 2000). It acts as both contact and stomach poison. Available information indicates that spinosad acts on the insect nervous system with the action on the nicotinic acetylcholine receptor and on GABA receptor.

Carbofuran
$C_{12}H_{15}NO_3$



Chemical name-
2,3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate.

Spinosad
$C_{41}H_{65}NO_{16}$ (Spinosyn A)
$C_{42}H_{67}NO_{16}$ (Spinosyn D)



i) R = H (Spinosyn A)
ii) R = CH_3 (Spinosyn D)

Chemical name-
It is a complex 'macrocyclic lactone'

Fig. 2. Chemical formula and structure of
C. Carbofuran
D. Spinosad

Technical name - Spinosad

Trade name - Tracer 48 SC®

Dose used - 750 ml/ha

Chemical name - It is a complex 'macrocyclic lactone'

Chemical formula and structure- Given in Fig. 2D.

Chemical class - Naturalyte

Source - De-Nocil Crop Protection Limited, Mumbai.

3.2.4.5. Polytrin C 44® (Profenophos 40 % + cypermethrin 4 %)

Dose used - 1000 ml/ha

Source - Novartis (Syngenta) India Ltd., Mumabi.

1. Profenophos :- It is a broad spectrum insecticide, non-systemic in nature. It also has ovicidal action. It acts as contact and stomach poison and is effective against sucking pests and caterpillars of lepidopteran pests.

Technical name - Profènophos

Chemical name - O - (4-bromo-2-chlorophenyl) O-ethyl S- propyl phosphorothioate.

Chemical formula and structure- Given in Fig. 2E.

Chemical class - Organophosphate

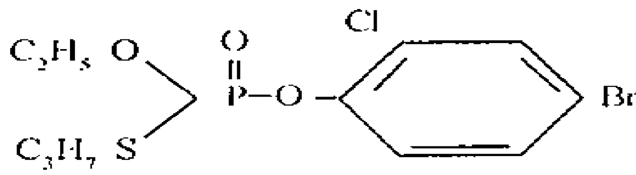
2. Cypermethrin :- It is a common insecticide from synthetic pyrethroids. It acts as a contact and stomach poison. It is very effective against wide range of insects. Especially the catterpillars of lepidopteran pests

Technical name - Cypermethrin

Chemical name - (RS)-a-cyno-3-phenoxybenzyl-(1 RS)-cis, trans-3-(2, 2 dichlorovinyl)-2,2-dimethyl cyclopropanecorboxylate.

Profenophos

$C_{11}H_{15}BrClO_3PS$

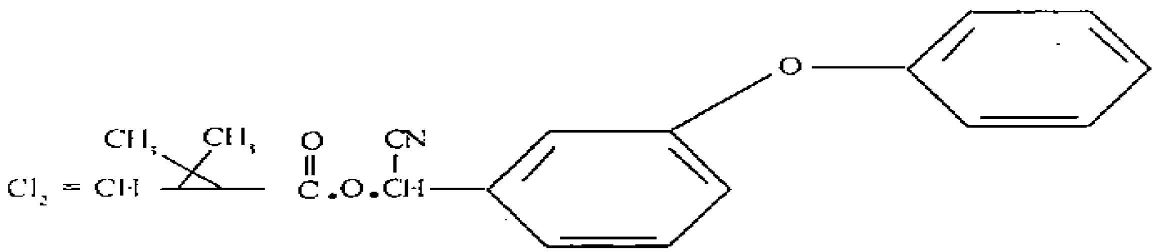


Chemical name-

O - (4-bromo-2-chlorophenyl) O-ethyl S- propyl phosphorothioate.

Cypermethrin

$C_{22}H_{19}Cl_2NO_3$

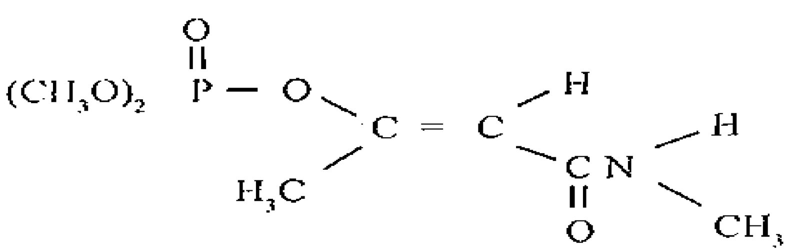


Chemical name-

(RS)-a-cyno-3-phenoxybenzyl-(1RS)-cis, trans-3-(2, 2 dichlorovinyl)-2,2-dimethyl cyclopropanecorboxylate.

Monocrotophos

$C_7H_{14}NO_5P$



Chemical name-

dimethyl (E)-1-methyl-2-methylcarba-moylvinyl phosphate.

Fig. 2. Chemical formula and structure of

E. Profenophos

F. Cypermethrin

G. Monocrotophos

Chemical formula and structure-		Given in Fig. 2F.
Chemical class	-	Synthetic pyrethroids

3.2.4.6. **Monocrotophos**

It is a systemic insecticide having contact action and widely used against a variety of insect pests from soft-bodied insects to leaf-eating beetles. It is also effective against borers and bollworms. It has acaricidal property also.

Technical name	-	Monocrotophos
Trade name	-	Nuvacron 36 SL®
Dose used	-	750 ml /ha
Chemical name	-	dimethyl (E)-1-methyl-2-methylcarbamoylvinyl phosphate.
Chemical formula and structure-		Given in Fig. 2G.
Chemical class	-	Organophosphate
Chemical subclass	-	Phosphate
Source	-	De-Nocil Crop Protection Limited, Mumbai.

3.2.5. **Seed dressing procedure**

3.2.5.1. **Seed dressing of imidacloprid and thiamethoxam**

For this purpose, weighed quantity of seed was taken in a plastic bag and weighed quantity of seed dresser was spread over it. Sufficient quantity of water was added with few drops of gum. Then the plastic bag was perfectly closed and shaken vigorously until uniform coating of the insecticide was formed over the seeds and was allow to dry overnight.

3.2.5.2. **Seed dressing of carbofuran**

The procedure for seed dressing of carbofuran was followed as per the recommendations of Marathwada Agricultural University, Parbhani, M.S. For this purpose, a paste was prepared by mixing the wheat flour in water with mild heating. weighed quantity of granular carbofuran 5 per cent was added to it and mixed thoroughly. Then this paste was evenly applied to the weighed quantity of seed and allowed to dry overnight.

3.2.6. Treatment application

Insecticidal treatments of spinosad, profenophos + cypermethrin and monocrotophos were applied at 15 days interval starting from 45 days after sowing. In all, three sprays were given during both years of investigation. The spray volume for each spray was calculated by spraying untreated plots with plain water just upto drip-off stage. Spraying was done in early morning hours to avoid the mid day heat. Measured quantity of insecticide was taken in 500 ml capacity beaker and mixed in small quantity of water and then added to a bucket containing known quantity of water. The spreader-cum-sticker 'Sandovit' was added @ 1ml/lit for effective sticking of spray suspension on the surface of the crop. The solution was stirred with a wooden stick and then poured in the spray tank using plastic funnel. Spraying was done using knapsack sprayer with solid cone nozzle.

3.2.7. Methods of recording observations

For recording observations, five plants from each plot were selected randomly and were tagged carefully.

3.2.7.1. Observations on sucking pests

Observations on the number of aphids, jassids (nymphs) and whiteflies were recorded from three leaves per plant, one each from top, middle and bottom canopy of the plant at 10 days interval starting from 15 days after sowing.

3.2.7.2. Observations on fruit damage

Observations on infestation of okra fruits caused by shoot and fruit borer, *E. vittella* were recorded at the time of each picking. For this, the infested and healthy fruits from each plot were weighed separately and per cent fruit infestation was worked out.

3.2.7.3. Observations on yield

The yield data on marketable quality fruits harvested at different pickings were recorded separately. Produce from all the pickings was totaled and yield per hectare was computed.

3.3 Economics of various treatment applications in okra pest management.

Taking into account the average price of okra in the market and expenditure incurred, marginal return and marginal cost was calculated and from these values the cost benefit ratios (CBR) were work out. So as to calculate the economics of different treatments, the cost of insecticides, labour charges and hiring charges of sprayer were summed up as marginal cost. The marginal product was calculated by subtracting control yield from treatment yield and its monetary value as marginal returns was also calculated by considering the average price of okra in the market. The marginal cost was subtracted from the marginal return to work out net return. The value of marginal return was divided by the value of marginal cost to get the cost benefit ratio.

Formulae

Marginal cost	=	Cost of insecticide + labour charges + hiring charges of sprayer.
Marginal product	=	Treatment yield - control yield
Marginal return	=	Monetary value of marginal product
Net return	=	Marginal return - marginal cost.

$$\text{Cost benefit ratio (CBR)} = \frac{\text{Marginal return}}{\text{Marginal cost}}$$

Cost Details

Imidacloprid (a.i.) - Rs. 17/g (Rs. 17000 /kg)

Thiamethoxam (a.i.) - Rs. 34/g (Rs. 170/5 g)

Carbofuran (Furadan 3G®) - Rs. 80 /kg

Spinosad (Tracer 48 SC®) - Rs. 1100 /100 ml.

Profenophos + Cypermethrin 44 EC (Polytrin C®) - Rs. 150 /250 ml.

Monocrotophos 36 SL (Nuvacron®) - Rs. 90/250 ml.

Labour charges

Rs. 50 /labour/day

2 labours/ha/spray

Hiring charges of knapsac sprayer - Rs. 60 /spray.

Market value of okra - Rs. 8/kg (Rs. 800/q)

3.4. Effect of different insecticidal treatments on larval parasitization of *E. vittella*

To study the effect of different insecticidal treatments on larval parasitoids of *E. vittella*, 10 larvae of fruit borer were collected weekly from each treatment and reared in laboratory till emergence of parasitoids or pupation. Observations were recorded for five weeks during both the years. Per cent parasitization were calculated and data transformed to angular values. Statistical analysis was carried out using Randomized Block Design technique.

3.5. Crop loss assessment due to key pests during various growth periods of okra

Insect injury of consists of the detrimental acts of insects, which causes damage to the plants. This would involve insect population and insect behaviour. Plant damage is the effect of the insect injury on the

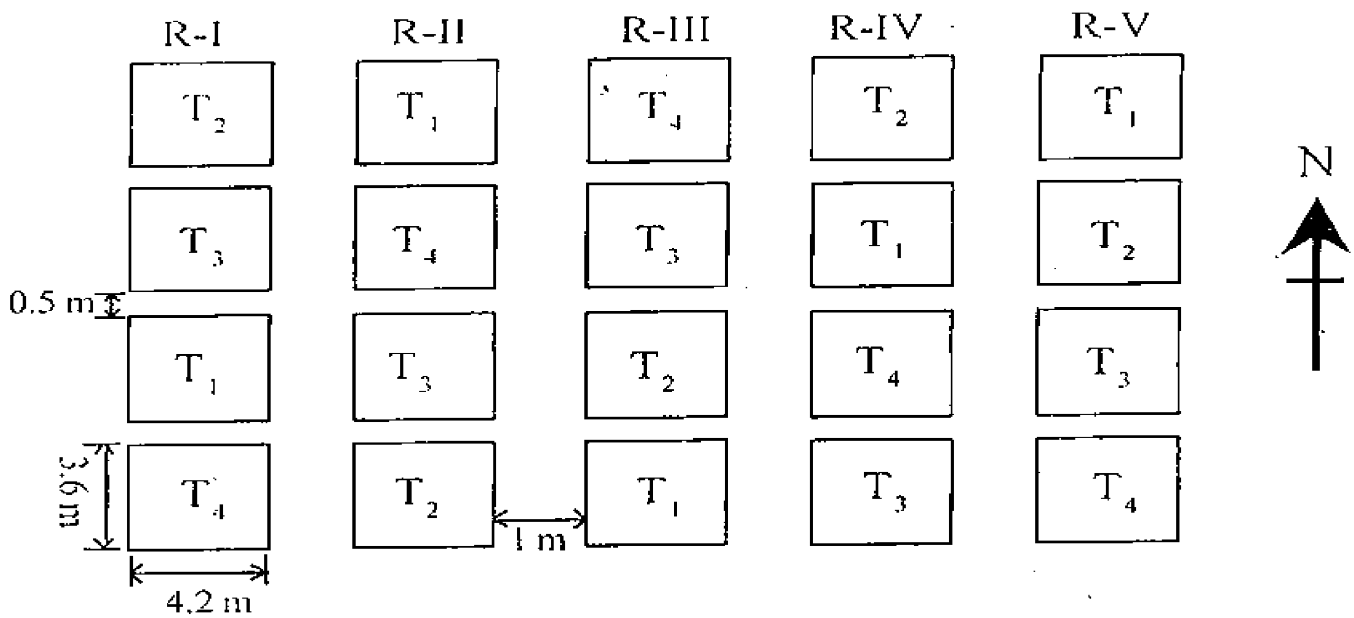


Fig. 3. Layout of crop loss assessment experiment

Tr. No.		Treatments
T_1	-	Protection during vegetative stage only
T_2	-	Protection during reproductive stage only
T_3	-	Protection throughout growth period
T_4	-	Untreated throughout growth period
Treatment details :		
T_1	-	Thiamethoxam 4 g a.i./kg seed treatment
T_2	-	Spinosad 48 SC @ 750 ml/ha
T_3	-	Thiamethoxam 4 g a.i./kg seed treatment + spinosad 48 SC @ 750 ml/ha
T_4	-	Untreated control.

plant. Plant damage may or may not result in crop losses. In some cases, the damage may even be beneficial. The term 'crop losses' considered to be qualitative and quantitative reduction in the yields, and the loss which can be avoided by applying chemical control measures against pests and diseases may be termed as 'avoidable loss' (Khosla, 1980).

Popular techniques of crop loss assessment by using pesticides as per LeClerg (1971) was followed with modifications in design to suit the requirements of present investigations i.e. instead of adopting paired plot, randomized block design was used to calculate the losses due to key pests of okra during various growth periods.

3.5.1. Experimental details

The field experiments were conducted during the summer seasons of 2000-2001 and 2001-2002, and laid out in a randomized block design with four treatments replicated five times. Gross plot size was 3.6 x 4.2 m^2. Spacing followed was 30 x 30 cm. The plan of layout is presented in Fig. 3.

Following treatments were included in the present investigation.

Tr. No.		Treatments
T_1	-	Protection during vegetative stage only
T_2	-	Protection during reproductive stage only
T_3	-	Protection throughout growth period
T_4	-	Untreated throughout growth period
Treatment details :		
T_1	-	Thiamethoxam 4 g a.i./kg seed treatment
T_2	-	Spinosad 48 SC @ 750 ml/ha
T_3	-	Thiamethoxam 4 g a.i./kg seed treatment + spinosad 48 SC @ 750 ml/ha
T_4	-	Untreated control.

3.5.2. Application of insecticides

In the treatment T_1, where the crop was protected during vegetative stage only, the seed was treated with thiamethoxam 4 g a.i./kg seed for controlling the sucking pests. In T_2, the crop was protected during fruiting stage only by giving sprays of spinosad 48 SC @ 750 ml/ha at 15 days interval starting from 45 DAS. In this treatment no protection was given in the vegetative stage. In T_3, the crop was protected completely throughout its growth period. The seed was treated with thiamethoxam 4 g a.i./kg to protect the crop against sucking pests. Thereafter to protect the crop in fruiting stage, spinosad 48 SC sprays @ 750 ml/ha were administered at 15 days interval starting from 45 DAS. In T_4, the crop was kept unprotected throughout the growing period.

3.5.3 Method of recording observations

Five plants were selected randomly from each plot and labelled. The observations recorded during the experimentations are as below.

3.5.3.1. Population of sucking pests

Population count of aphids, jassids (nymphs) and whiteflies were taken weekly from six leaves (two each from top, middle and bottom canopy of plant) on five tagged plants per plot selected at random commencing from 15 to 40 days of sowing.

3.5.3.2. Infestation of fruit borer

During each harvest carried out at 3 to 4 days interval, borer affected fruits and healthy fruits from individual plot were weighed. The percentage of borer infestation was calculated on the basis of cumulative data for all the pickings. The data on percentage fruit borer infestation were transformed to angular values before statistical analysis.

3.5.3.3. Biometrical observations

Observations on the plant height and number of leaves per plant were recorded at weekly interval throughout the crop life. The observations on the average leaf area and fresh leaf weight per plant were recorded on 40 days after sowing.

3.5.4 Method used for assessing per cent crop loss

Judenko (1972) expressed the percentage yield loss per plant by the coefficient of harmfulness (C) :

$$C = \frac{(a - b) \times 100}{a}$$

Where,

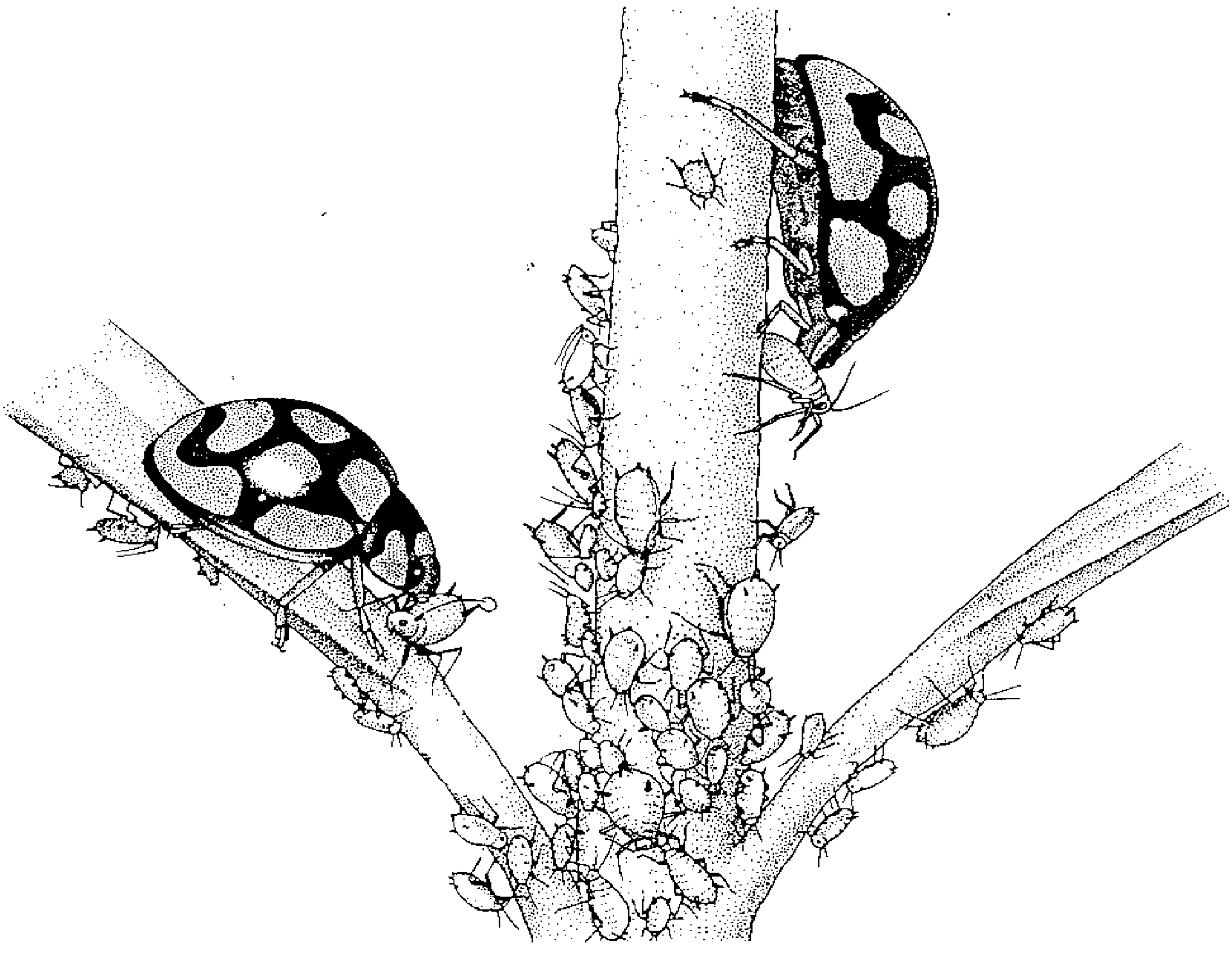
a = Mean yield of unattacked plants

b = Mean yield of attacked plants.

The same method was adopted to assess the losses in various parameters studied. The per cent loss was calculated by comparing the various treatments to the treatment that afforded maximum protection and maximum increase in plant characters and yield. In such a treatment the avoidable loss was considered as nil.

3.5.5. Statistical analysis

The data were statistically analysed by standard "analysis of variance" method. (Panse and Sukhatme, 1967).



RESULTS

CHAPTER IV

RESULTS

The results obtained during the present investigations are presented under the following heads.

4.1. Population dynamics of key pests of okra

4.2. Bioefficacy of newer insecticides against key pests of okra.

4.3 Effect of different insecticidal treatments on marketable fruit yield of okra.

4.4. Economics of various treatment applications in okra pest management

4.5. Effect of different insecticidal treatments on parasitization of *Earias vittella*.

4.6. Crop loss assessment due to key pests during various growth periods of okra.

4.1 Population dynamics of key pests of okra

4.1.1 Population dynamics of key pests of okra during 2000- 2001.

4.1.1.1 Population dynamics of aphids, *Aphis gossypii* during 2000-2001

The data on population fluctuations of okra aphid, *A. gossypii* during summer season of 2000-2001 (Table 1, Fig. 4 and Appendix I) revealed that the aphid population ranged between 0.00 to 16.10 aphids / three leaves. Incidence of aphids started from 10th MW (0.05 aphids/ three leaves) when the prevailing rainfall, maximum-minimum temperature, morning and evening RH and bright sunshine hours were 0.00 mm, 34.8 °C, 16.6 °C, 55 per cent, 26 per cent and 10.5 hrs / day, respectively. There after the population rose to peak (16.10 aphids/ leaves) during the 18th MW when the prevailing rainfall, maximum- minimum temperature, morning -evening RH and bright sunshine hours were 0.00 mm, 43.2°C, 24.5°C, 33%, 17% and 11.6 hrs/day, respectively. The population declined steadily thereafter touching 14.00 aphids/ three leaves during 20th meteorological week.

Table 1. Population dynamics of key pests of okra during summer 2000-2001

Sr. No.	Meteorological week and duration	No. of aphids / three leaves	No. of jassids (nymphs) /three leaves	No. of whiteflies / three leaves	Per cent fruit borer infestation
1.	9 (26 Feb-4 Mar.)	0.00	0.10	0.60	0.00
2.	10(5 Mar.-11 Mar.)	0.05	1.55	0.30	0.00
3.	11(12 Mar.-18 Mar.)	2.55	2.30	3.00	0.00
4.	12(19 Mar.-25 Mar.)	6.85	3.10	4.60	0.00
5.	13(26 Mar.- 1 April)	8.60	6.00	5.00	0.00
6.	14(2 April - 8 April)	10.75	16.50	6.00	15.01
7.	15(9 April - 15 April)	13.20	11.90	6.40	27.20
8.	16 (16 April-22 April)	13.49	18.20	6.90	40.10
9.	17 (23 April-29 April)	15.20	19.30	7.40	45.40
10.	18(30 April - 6 May)	16.10	25.10	9.20	57.80
11.	19(7 May-13 May)	14.40	24.70	8.70	53.20
12.	20(14 May - 20 May)	14.00	22.00	7.90	51.10

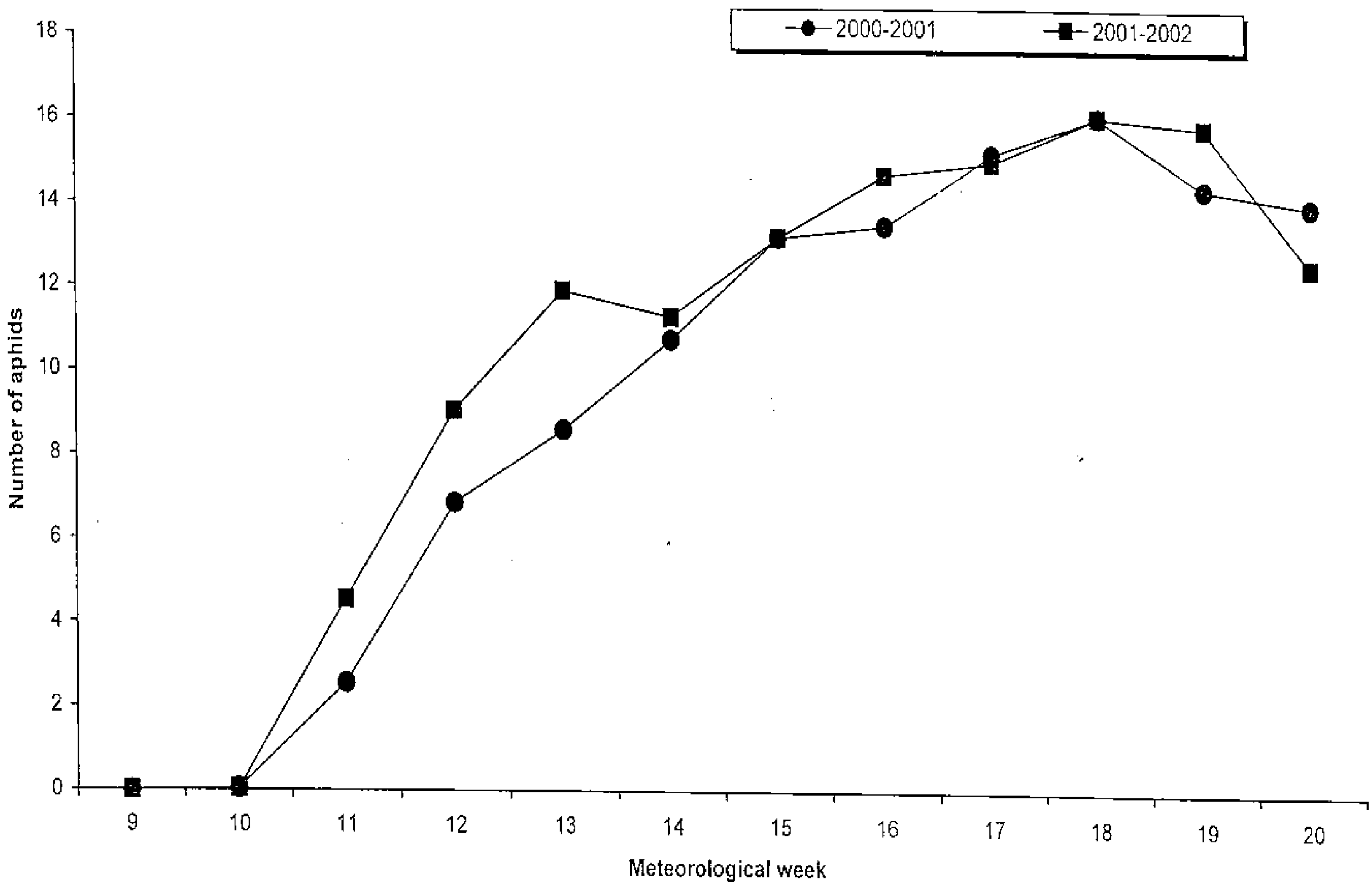


Fig.4. Population dynamic aphids on okra in different meteorological weeks during 2000-2001 and 2001-2002

4.1.1.1.1 Correlation and regression studies between weather parameters and aphid population during 2000-2001

4.1.1.1.1.1 Correlation studies

The data on correlation and regression coefficients between weather parameters and aphid population are presented in Table 2. The results brought out significant positive correlation between aphid population and maximum temperature (r = 0.788**). Correlation of rainfall, minimum temperature and bright sunshine hours with aphid population were positive but non-significant. Whereas, the morning and evening relative humidity showed negative non-significant correlation with aphid population.

4.1.1.1.1.2 Regression studies

Simple regression was worked out between the weather parameters and the incidence of aphids. The regression coefficients 'b' and constant 'a' were worked out and simple regression equations were set up (Table 2). Except the maximum temperature, the impact of all other weather factors on incidence of aphids was non significant.

The correlation between maximum temperature (x) and aphid population (y) was found to be significant and positive (r = 0.788**). The regression equation worked out was y = -52.86 + 1.631 x which indicated that for every unit increase in maximum temperature, the aphid population increased by 1.631.

4.1.1.2 Population dynamics of jassids, *Amrasca biguttulla biguttulla* during 2000-2001.

The incidence of jassids started during 9th MW recording 0.10 jassids/ three leaves, when the prevailing rainfall, maximum-minimum temperature, morning- evening RH and bright sunshine hours were 0.00 mm, 35.4°C, 16.4°C, 60 per cent, 28 per cent and 11.0 hrs/day (Table 1 and Fig. 5). Thereafter the population rose

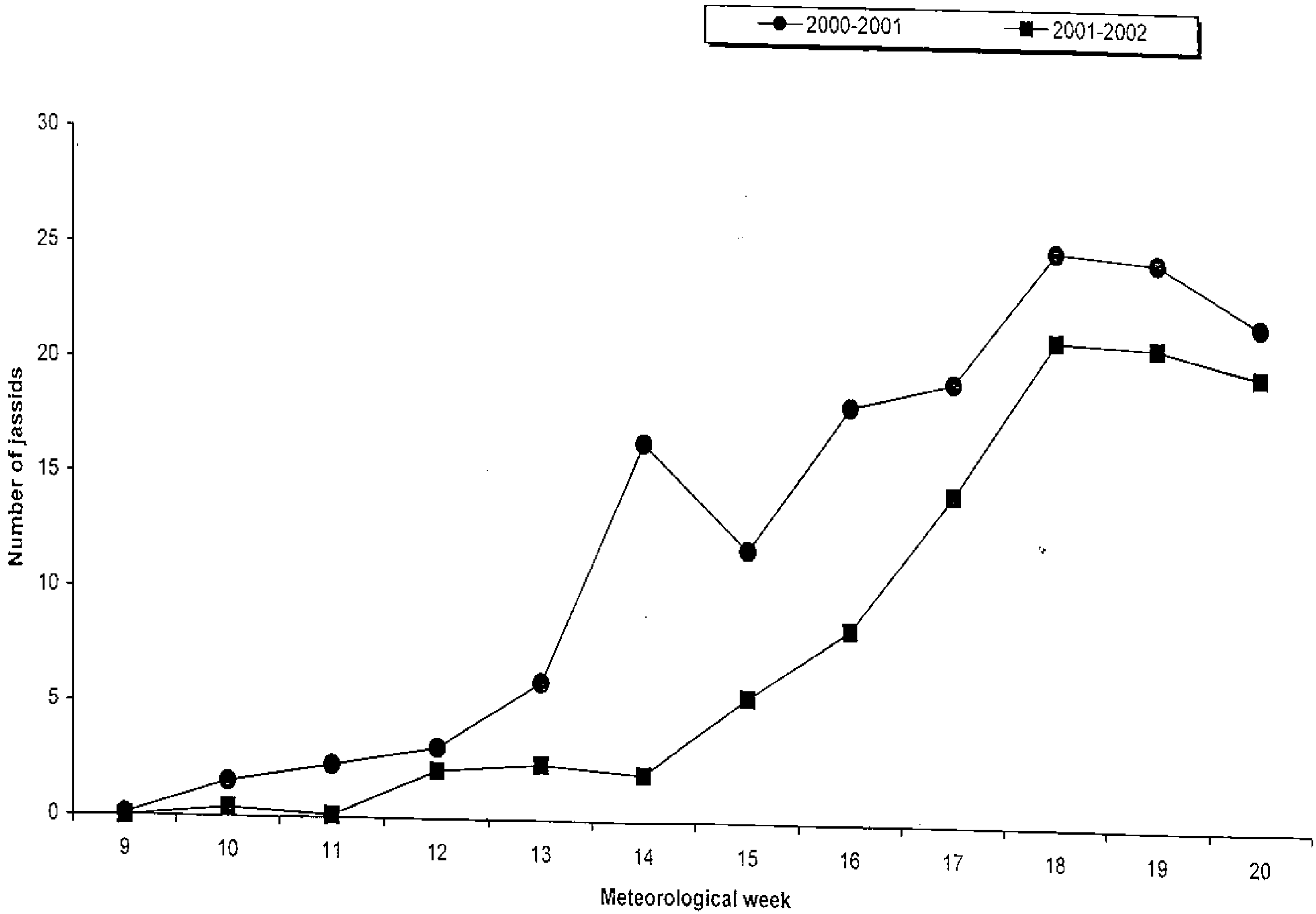


Fig.5. Population dynamic jassids on okra in different meteorological weeks during 2000-2001 and 2001-2002

Table 2. Correlation and regression coefficients between weather parameters and key pests of okra (2000-2001)

Weather Parameters	Aphid population			Jassid (nymph)population			Whitefly population			*E. vittella* fruit infestation		
	r	b	a	r	b	a	r	b	a	r	b	a
Rainfall (mm)	0.078	0.147	9.455	0.000	0.002	12.56	0.073	0.067	5.434	0.00	-0.779	24.86
Temp. °C Max.	0.788**	1.631	-52.86	0.836**	2.784	-94.01	0.841**	0.861	-24.47	0.80**	7.228	-252.6
Temp. °C Min.	0.485	0.508	-1.890	0.354	0.597	-0.919	0.501	0.259	-0.366	0.20	1.097	-0.623
R.H. (%) AM	-0.401	-0.154	16.18	-0.274	-0.169	19.80	-0.440	-0.083	9.070	-0.20	-0.440	42.91
R.H. (%) PM	-0.166	-0.126	12.20	0.012	0.015	12.25	-0.215	-0.080	7.160	0.00	0.005	24.04
BSS (hr./day)	0.132	0.773	1.248	0.224	2.104	-10.16	0.212	0.611	-1.107	-0.30	7.592	-57.84
Number of observations	12	12	12	12	12	12	12	12	12	12	12	12

* Significant at 5 %
** Highly significant at 1 %
R.H. = Relative humidity
BSS = Bright Sunshine hours

r = Correlation coefficient
b = regression coefficient
a = constant

steadily showing a smaller peak in 14th MW (16.10 jassids / three leaves). In next week (15th MW) the population decreased to 11.90 jassids / three leaves. The highest jassids population was recorded in the 18th MW (25.10 jassids /three leaves) when the prevailing rainfall, max.-min. temperature, morning-evening relative humidity and bright sunshine hours were 0.00 mm, 43.2°C, 24.5°C, 33 per cent, 17 per cent and 11.6 hrs/day, respectively.

4.1.1.2.1 Correlation and regression studies between weather parameters and jassid population during 2000-2001

4.1.1.2.1.1 Correlation studies

The data on correlation and regression coefficients between weather parameters and jassid population are presented in Table 2. The results indicated that the correlation of jassid population with maximum temperature was significant and positive (r = 0.836**). All other weather parameters except morning relative humidity showed positive but non-significant correlation with jassid population. The morning RH showed negative and non-significant correlation.

4.1.1.2.1.2 Regression studies

The simple regression equation worked out for maximum temperature was y = -94.01 + 2.784x indicating 2.784 increase in jassid population for every unit increase in the maximum temperature. The impact of all other weather factors on the incidence of jassids was non significant.

4.1.1.3 Population dynamics of whiteflies, *Bemisia tabaci* during 2000-2001

The incidence of whitefly started from 9th MW (0.60 whiteflies /three leaves) (Table 1 and Fig. 6). In the next Meteorological Week (10th) the whitefly population decreased slightly to 0.30 whiteflies/three leaves. Thereafter the population increased steadily reaching its peak (9.20

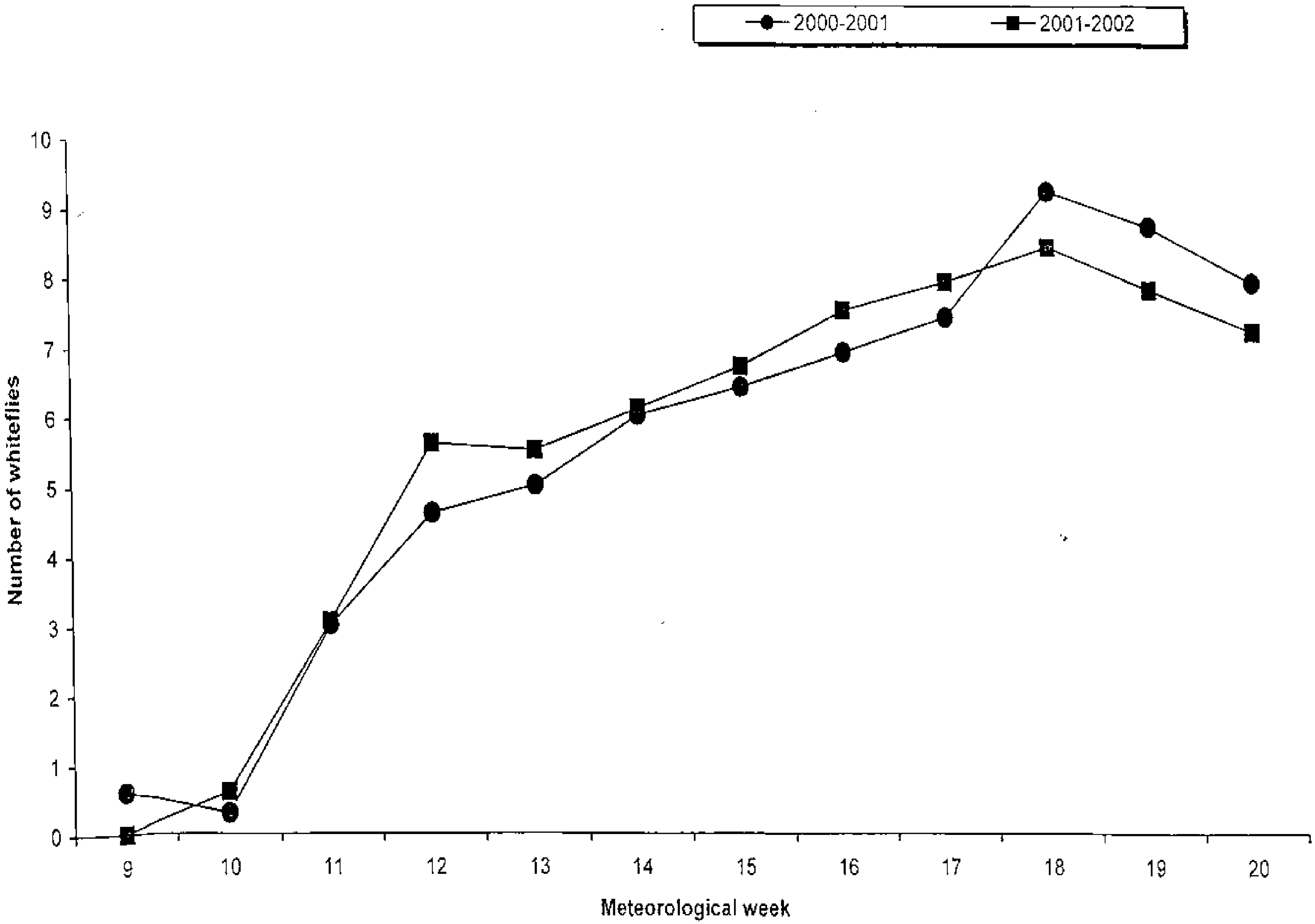


Fig.6. Population dynamic whiteflies on okra in different meteorological weeks during 2000-2001 and 2001-2002.

whiteflies/three leaves) in the 18th MW when the corresponding rainfall, maximum - minimum temperature, morning-evening RH and BSS were 0.0 mm, 43.2°C, 24.5°C, 33 per cent, 17 per cent and 11.6 hrs/day, respectively. From 17th MW, the whitefly population remained more or less constant.

4.1.1.3.1 Correlation and regression studies between weather parameters and whitefly population during 2000-2001

4.1.1.3.1.1 Correlation studies

The observations on the correlation and regression coefficients between weather parameters and whitefly population for the year 2000-2001 are presented in Table 2. Only the maximum temperature showed the significant positive correlation (r = 0.841**).

4.1.3.2. Regression studies

Simple regression was worked out between whitefly population and weather factors. The regression coefficient 'b' and constant 'a' were worked out and simple regression equations were set up. Rainfall, minimum temperature, and bright sunshine hours showed non-significant positive impact on whitefly population. The impact of morning and evening RH was negative and non-significant.

The regression equation worked out for maximum temperature and whitefly population was $y = -24.47 + 0.861\ x$ which indicated that for every unit increase in the maximum temperature, the whitefly population increased by 0.861.

4.1.1.4 Population dynamics of *E. vittella* (per cent fruit infestation during 2000-2001)

The data pertaining to per cent fruit infestation by *E. vittella* during summer season of 2000-2001 are presented in Table 1 and Fig. 7.

It is evident from the data that the fruit infestation ranged from 15.01 to 57.80 per cent. The lowest fruit infestation (15.01 per cent) was recorded in the 14th MW when the prevailing rainfall, maximum - minimum temperature, morning-evening RH and BSS were 11.0 mm, 36.2°C, 20.5°C, 60 per cent, 31 per cent and 9.1 hrs/day, respectively. In 15th and 16th MW the fruit infestation increased fastly and recorded 27.20 and 40.10 per cent fruit infestation, respectively. The highest fruit infestation (57.80 per cent) was recorded in the 18th MW when the corresponding rainfall, maximum-minimum, temperature, morning -evening RH and BSS were 0.0 mm, 43.2°C, 24.5°C, 33 per cent, 17 per cent and 11.6 hrs/day, respectively. Thereafter the per cent fruit infestation decreased very slowly.

4.1.1.4.1 Correlation and regression studies between weather parameters and per cent fruit infestation during 2000-2001

4.1.1.4.1.1 Correlation studies

The pertinent data on per cent fruit infestation and correlation and regression coefficients are presented in Table 2. Significant positive correlationship was observed between per cent fruit infestation and maximum temperature (r = 0.80**). All other weather parameters except morning RH showed positive and non-significant correlation. Whereas the correlation between morning RH and per cent fruit infestation was negative and non significant.

4.1.1.4.1.2 Regression studies

Simple regression equation worked out for maximum temperature and per cent fruit infestation was y = -252.6 + 7.228 x indicating 7.228 per cent increase in fruit infestation for every unit increase in the maximum temperature (Table 2).

4.1.2. Population dynamics of key pests of okra during 2001-2002

4.1.2.1 Population dynamics of aphids, *Aphis gossypii* during 2001-2002

The data from Table 3 revealed that the aphid incidence started in 10th MW (0.05 aphids/three leaves) when the corresponding rainfall, maximum - minimum temperature, morning-evening relative humidity and BSS were 0.0 mm, 36.0°C, 15.7°C, 54 per cent, 19 per cent and 10.9 hrs/days, respectively (Fig. 4 and Appendix II).

Table 3. Population dynamics of key pests of okra during summer 2001-2002

Sr. No.	Meteorological week and duration	No. of aphids / three leaves	No. of jassids (nymphs) /three leaves	No. of whiteflies / three leaves	Per cent fruit borer infestation
1.	9 (26 Feb-4 Mar.)	0.00	0.00	0.00	0.00
2.	10(5 Mar.-11 Mar.)	0.05	0.40	0.60	0.00
3.	11(12 Mar.-18 Mar.)	4.55	0.10	3.05	0.00
4.	12(19 Mar.-25 Mar.)	9.05	2.10	5.60	0.00
5.	13(26 Mar.- 1 April)	11.90	2.40	5.50	0.00
6.	14(2 April - 8 April)	11.30	2.05	6.10	0.00
7.	15(9 April - 15 April)	13.20	5.45	6.70	25.85
8.	16 (16 April-22 April)	14.70	8.50	7.50	31.40
9.	17 (23 April-29 April)	15.00	14.40	7.90	42.00
10.	18(30 April - 6 May)	16.10	21.20	8.40	51.30
11.	19(7 May-13 May)	15.85	21.00	7.80	48.40
12.	20(14 May - 20 May)	12.56	19.80	7.20	48.10

Thereafter the population rose slowly upto 13th MW (11.90 aphids/three leaves). In 14th MW, the population decreased slightly (11.30

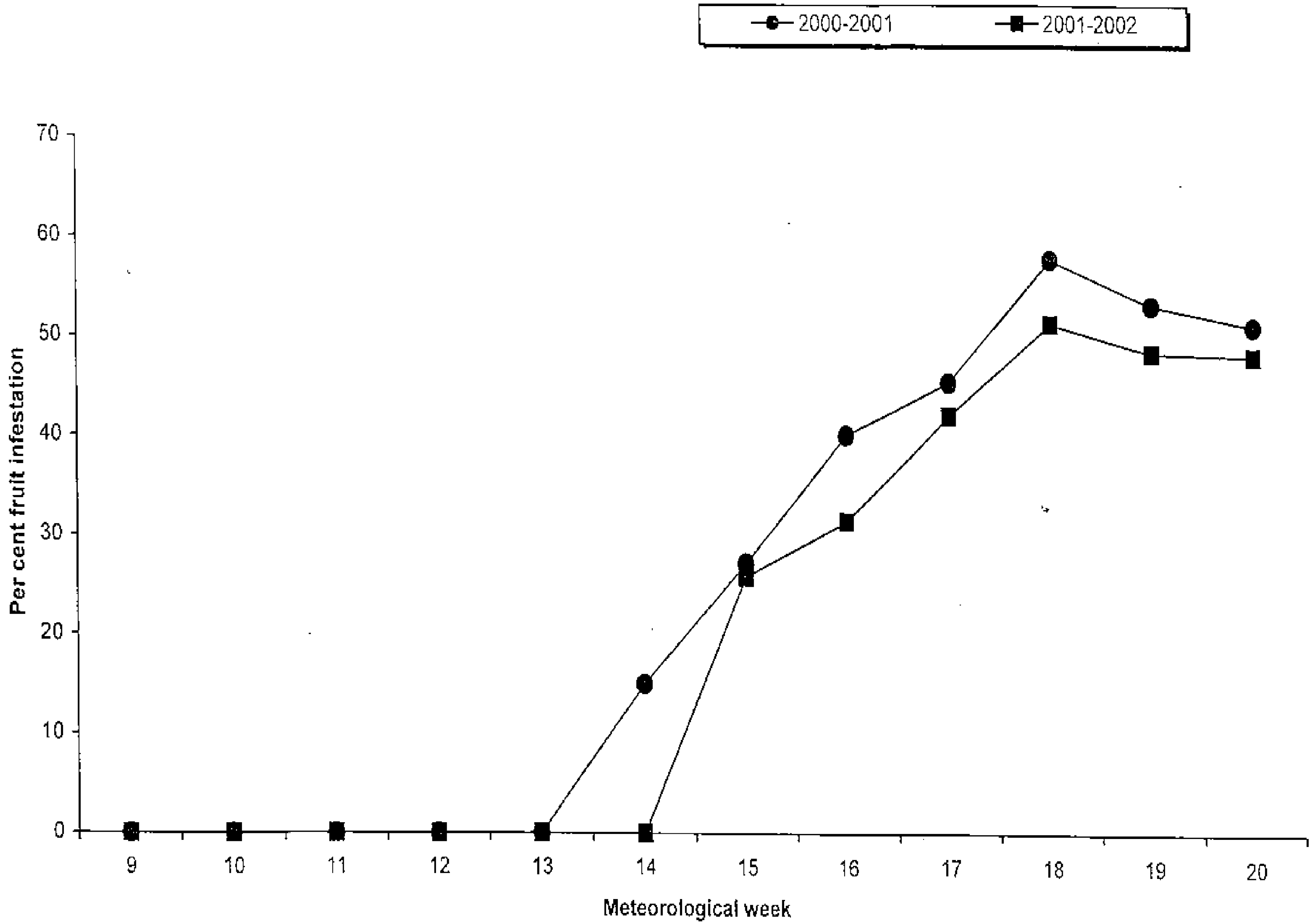


Fig.7. Population dynamic of *E. vittella* (per cent fruit infestation) on okra in different meteorological weeks during 2000-2001 and 2001-2002.

aphids/ three leaves). Highest aphid population (16.10 aphids/three leaves) was recorded in the 18th MW when the prevailing rainfall, maximum-minimum temperature, morning - evening RH and BSS were 0.0 mm, 43.9°C, 26.3°C, 40 per cent, 13 per cent and 10.9 hrs/day, respectively. Thereafter the population decreased slowly upto the end of crop.

4.1.2.1.1. Correlation and regression studies between weather parameters and aphid population during 2001-2002

4.1.2.1.1.1 Correlation studies

The data on correlation and regression coefficient between weather parameters and aphid population are presented in Table 4. The results brought out significant positive correlation between aphid population and maximum and minimum temperature (r = 0.921**, 0.801**, respectively). Correlation of morning and evening RH was negative and non-significant whereas, rainfall and BSS showed positive but non-significant correlation with the aphid population.

4.1.2.1.1.2. Regression studies

Simple regression was worked out between weather parameters and incidence of aphids. The regression coefficients 'b' and constants 'a' were worked out and simple regression equations were set up (Table 4). Only the maximum and minimum temperature showed significant positive impact. The regression equation worked out for maximum temperature (x) and aphid population (y) was $y = -67.88 + 1.977x$ which indicated that the aphid population increased by 1.977 for every unit increase in maximum temperature. The regression equation worked out for minimum temperature was $y = -10.26 + 0.973x$.

Table 4. Correlation and regression coefficients between weather parameters and key pests of okra (2001-2002)

Weather Parameters	Aphid population			Jassid (nymph)population			Whitefly population			*E. vittella* fruit infestation		
	r	b	a	r	b	a	r	b	a	r	b	a
Rainfall (mm)	0.063	2.437	10.06	-0.222	-13.24	8.668	0.063	1.245	5.477	-0.20	-45.10	22.55
Temp. ^{0}C Max.	0.921**	1.977	-67.88	0.866**	2.843	-104.1	0.925**	-0.999	33.92	0.80**	7.475	- 274.4
Temp. ^{0}C Min.	0.801**	0.973	-10.26	0.859**	1.597	-25.38	0.819**	0.500	- 4.977	0.80**	4.206	- 67.58
R.H. (%) AM	-0.553	-0.416	31.22	-0.236	-0.271	21.84	-0.522	-0.197	15.52	-0.30	-0.967	69.51
R.H. (%) PM	-0.282	-0.488	18.99	-0.266	-0.702	20.82	-0.269	-0.233	9.756	-0.30	-2.265	61.64
BSS (hr./day)	0.134	0.969	-0.279	0.133	1.477	-7.796	0.087	0.316	2.125	0.10	3.208	- 13.90
Number of observations	12	12	12	12	12	12	12	12	12	12	12	12

* Significant at 5 %
** Highly significant at 1 %
R.H. = Relative humidity
BSS = Bright Sunshine hours

r = Correlation coefficient
b = regression coefficient
a = constant

4.1.2.2. Population dynamics of jassid, *Amrasca biguttulla biguttulla* during 2001-2002

The observations on the jassid population (Table 3 and Fig. 5) indicated that the jassid attack started in 10th MW recording 0.40 jassids / three leaves when the prevailing rainfall, maximum-minimum temperature, morning-evening RH and BSS were 0.0 mm, 36.0°C, 15.7°C, 54 per cent, 19 per cent and 10.9 hrs/day, respectively. In the next week (11th MW), the jassid population decreased slightly (0.10 jassids/three leaves). Thereafter the population rose steadily and reached its peak (21.20 jassids / three leaves) during 18th MW. In this, a slight reduction in the jassid population (2.05 jassids/three leaves) was observed during 14th MW when the corresponding rainfall, maximum-minimum temperature, morning - evening RH, and BSS were 0.5 mm, 39.8°C, 21.5°C, 53 per cent, 20 per cent and 10.0 hrs/day, respectively. After 18th MW, the population remained more or less constant.

4.1.2.2.1. Correlation and regression studies between weather parameters and jassid population during 2001-2002

4.1.2.2.1.1. Correlation studies

The data on correlation and regression coefficients between jassid population and weather parameters are presented in Table 4. The results showed that the correlation of jassid population with maximum and minimum temperature were positive and significant (r = 0.866** and r = 0.859**, respectively). Rest of the weather factors showed non-significant association with jassid population.

4.1.2.2.1.2. Regression studies

The regression equations were set up by working out regression coefficients (b) and constants (a). The regression equation for maximum and minimum temperature were $y = -104.1 + 2.843\ x$ and $y = -25.38 + 1.597\ x$, respectively.

4.1.2.3. Population dynamics of whitefly, *B. tabaci* during 2001-2002

The data from Table 3 revealed that during summer season of 2001-2002, the whitefly population ranged between 0.60 to 8.40 whiteflies/three leaves. The lowest population (0.60 / three leaves) was recorded during 10th MW when the prevailing rainfall, maximum -minimum temperature , morning -evening RH and BSS were 0.0 mm, 36.0°C, 15.7°C, 54 per cent, 19 per cent and 10.9 hrs/day, respectively. The population increased thereafter steadily and reached its peak (8.40 whiteflies / three leaves) in the 18th MW (30 April to 6 May) (Fig. 6).

4.1.2.3.1. Correlation and regression studies between weather parameters and whitefly population during 2001-2002

4.1.2.3.1.1. Correlation studies

The corresponding data on correlation and regression coefficients between whitefly population and weather parameter (Table 4) indicated that the correlation of whitefly population with maximum and minimum temperature was positive and significant (r = 0.925** and 0.819**, respectively). Rest of the weather parameters showed non-significant correlation with whitefly population.

4.1.2.3.1.2. Regression studies

The impact of all weather parameters except maximum and minimum temperature on whitefly population was non-significant. The regression equation worked out for maximum temperature was y = 33.92 - 0.999 x and for minimum temperature was y = -4.977 + 0.500 x.

4.1.2.4. Population dynamics of *E. vittella* (per cent fruit infestation) during 2001-2002

The data on per cent fruit infestation by *E. vittella* (Table 3 and Fig. 7) indicated that the fruit infestation ranged between 25.85 to 51.30 per cent. From 15th MW onwards, the per cent fruit infestation rose slowly and reached its peak (51.70 per cent) during 18th MW. From 16th to 17th MW, the fruit infestation increased considerably (31.40 to 42.00 per cent). when the prevailing rainfall, maximum-minimum temperature, morning - evening RH, and BSS were 0.0 mm, 42.2°C, 20.9°C, 39 per cent, 14 per cent and 11.9 hrs/day, respectively. Thereafter, the per cent fruit infestation decreased slowly upto the end of crop.

4.1.2.4.1. Correlation and regression studies between weather parameters and per cent fruit infestation during 2001-2002

4.1.2.4.1.1. Correlation studies

The data on per cent fruit infestation and correlation and regression coefficients are presented in Table 4. The significant positive correlationship was observed between per cent fruit infestation and maximum and minimum temperature (r = 0.80** each). All other weather parameters showed non-significant correlation with per cent fruit infestation.

4.1.2.4.1.2. Regression studies

Simple regression equations were set up by finding out regression coefficient (b) and constant (a). The regression equation for maximum temperature was found to be $y = -274.4 + 7.475\ x$ which indicated that for every unit increase in maximum temperature, the fruit infestation increased by 7.47 per cent. The regression equation for minimum temperature was $y = -67.58 + 4.206\ x$ indicating 4.206 per cent increase in fruit infestation for every unit increase in minimum temperature.

4.1.3 Correlation and regression studies between weather parameters and key pests of okra for the year 2000-2001 and 2001-2002 (Pooled)

4.1.3.1 Correlation and regression studies between weather parameters and incidence of aphids, *A. gossypii*.

4.1.3.1.1 Correlation studies

The data on correlation and regression coefficients between weather parameters and aphid population are presented in Table 5. The results indicated that aphid population showed significant positive correlations with maximum and minimum temperature (r = 0.835** and 0.821** respectively). The correlation with morning relative humidity was significant but negative (r = -0.667**) whereas that of with evening relative humidity, it was negative and non significant. Rest of the weather parameters showed non-significant correlation with aphid population.

4.1.3.1.2 Regression studies

Simple regression was worked out between weather parameters and incidence of aphids. The regression coefficients 'b' and constant 'a' were worked out and simple regression equations were set up (Table 5). Maximum and minimum temperature had significant positive impact whereas morning relative humidity had significant but negative effect on the aphid population. The regression equations worked out for maximum temperature, minimum temperature and morning relative humidity were $y = -55.28 + 1.674\ x$, $y = -14.42 + 1.160\ x$ and $y = 30.61 - 0.4285\ x$, respectively which indicated that for every unit increase in maximum and minimum temperature, the aphid population increased by 1.674 and 1.160, respectively and for every unit increase in morning relative humidity, the aphid population decreased by 0.4285.

Table 5. Correlation and regression coefficients between weather parameters and key pests of okra for the year 2000-2001 and 2001-2002 (pooled)

Weather Parameters	Aphid population			Jassid (nymph)population			Whitefly population			*E. vittella* fruit infestation		
	r	b	a	r	b	a	r	b	a	r	b	a
Rainfall (mm)	0.111	0.2025	9.673	0.185	0.5435	9.776	0.139	0.1256	5.384	0.135	0.9974	21.38
Temp. ^{0}C Max.	0.835**	1.674	-55.28	0.748**	2.428	-84.18	0.854**	0.8528	-27.68	0.818**	6.662	-236.9
Temp. ^{0}C Min.	0.821**	1.160	-14.42	0.847**	1.937	-30.24	0.844**	0.5937	-6.924	0.877**	5.031	-82.98
R.H. (%) AM	-0.667**	-0.4285	30.61	-0.613**	-0.6379	41.20	-0.663**	-0.2120	15.77	-0.621**	-1.620	100.8
R.H. (%) PM	-0.266	-0.2889	15.80	-0.037	-0.0656	11.68	-0.241	-0.1302	8.183	-0.129	-0.5681	34.06
BSS (hr./day)	0.131	0.8408	0.8133	0.184	1.909	-10.26	0.158	0.5023	0.0961	0.231	6.002	-42.34
Number of observations	24	24	24	24	24	24	24	24	24	24	24	24

* Significant at 5 %
** Highly significant at 1 %
R.H. = Relative humidity
BSS = Bright Sunshine hours

r = Correlation coefficient
b = regression coefficient
a = constant

4.1.3.2 Correlation and regression studies between weather parameters and incidence of jassids

4.1.3.2.1 Correlation studies

The pertaining data presented in Table 5 brought out significant positive correlation between jassid population and maximum and minimum temperature (r = 0.748** and 0.847**). The correlation of jassid population with morning relative humidity was significant but negative (r = - 0.613**). Rest of the weather factors showed non-significant correlation with jassid population.

4.1.3.2.2 Regression studies

The simple regression equations were set up by calculating regression coefficients 'b' and constants 'a'. Only maximum temperature, minimum temperature and morning relative humidity showed significant effect on the jassid population. The simple regression equations worked out for maximum temperature, minimum temperature and morning relative humidity were $y = -84.18 + 2.428\ x$, $y = -30.24 + 1.937x$ and $y = 41.20 - 0.6379\ x$. These equations revealed that for every unit increase in the above parameters, the jassid population increased by 2.428, 1.937 and decreased by 0.6379, respectively.

4.1.3.3 Correlation and regression studies between weather parameters and incidence of whitefly

4.1.3.3.1 Correlation studies

The data on correlation and regression coefficients between weather parameters and whitefly population are presented in Table 5. The results brought out significant positive correlation between whitefly population and maximum and minimum temperature (r = 0.854** and 0.844**, respectively). Though the correlation with morning relative humidity was significant but it has negative impact (r = - 0.663**). Evening relative humidity had negative and non-significant correlation whereas rainfall and bright sunshine hours had positive but non-significant correlation with the pest population.

4.1.3.3.2 Regression studies

The simple regression equations worked out for maximum, minimum temperature and morning relative humidity were $y = -27.68 + 0.8528x$, $y = -6.924 + 0.5937x$ and $y = 15.77 - 0.2120x$, respectively indicating 0.8528, 0.5937 increase and 0.2120 decrease in the whitefly population for every unit increase in the maximum - minimum temperature and morning relative humidity. Rest of the abiotic factors have non-significant impact on pest population.

4.1.3.4 Correlation and regression studies between weather parameters and per cent fruit infestation

4.1.3.4.1 Correlation studies

The data on correlation between weather parameters and per cent fruit infestation (Table 5) revealed that there is significant positive correlation between maximum-minimum temperature and per cent fruit infestation (r = 0.818** and 0.877**, respectively). The correlation with morning relative humidity was significant but negative (r = -0.621**). Rest of the weather factors showed non-significant correlation with per cent fruit infestation.

4.1.3.4.2 Regression studies.

The simple regression equations were worked out by calculating regression coefficients 'b' and constant 'a' (Table 5). Only maximum and minimum temperature showed positive and significant impact on per cent fruit infestation. The simple regression equations worked out for maximum and minimum temperature were $y = -236.9 + 6.662x$ and $y = -82.98 + 5.031x$ indicating 6.62 % and 5.031 % increase in fruit infestation for every unit increase in above weather factors respectively. The morning relative humidity brought out significant but negative impact on fruit infestation. The simple regression equation worked out was y = 100.8 - 1.620 x *which revealed that for* every unit increase in morning relative humidity, the fruit infestation decreased by 1.620 per cent. Remaining weather factors showed non-significant effect on fruit infestation.

4.2. Bioefficacy of newer insecticides against key pests of okra

4.2.1. Bioefficacy of seed dressers against sucking pests of okra

In this experiment, the response of the different systemic insecticides as seed dressers for the control of sucking pests of okra was measured in terms of pest population survived on the plants after a specified period i.e. 15, 25 and 35 DAS (Days after sowing).

4.2.1.1. Bioefficacy of seed dressers against aphids

4.2.1.1.1. Bioefficacy of seed dressers against aphids, *A. gossypii*, during 2000-2001

It is evident from Table 6 that all the treatments were significantly superior over control at 15 DAS in reducing the aphid population except the treatment T_7 (Carbofuran 3G @ 5 per cent seed treatment) which was at par with the control. The lowest aphid population (0.06 aphids/leaf) was recorded in the treatment T_5 (thiamethoxam @ 4 g a.i./kg seed).

The aphid population at 25 DAS ranged between 1.20 to 5.20 aphids /leaf. All the treatments were significantly superior over control in reducing aphid population. The lowest aphid population (1.20 aphids /leaf) was recorded in the treatment T_5 (thiamethoxam @ 4 g a.i./kg seed), followed by the treatments of thiamethoxam @ 4 g a.i. /kg seed treatment (T_4, T_6) and imidacloprid @ 10 g a.i. /kg seed treatment (T_2 and T_3) which were at par with each other. The least effective treatments were of carbofuran 3 G @ 5 % seed treatment (T_7, T_8 and T_9) all of which were at par with each other. The highest aphid population (5.20 aphids/leaf) was recorded in untreated control.

Table 6. Bioefficacy of seed dressers against aphids, *A. gossypii* during 2000-2001

Treatment	Number of aphids /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.80 (1.13)*	2.80 (1.79)	4.46 (2.22)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.73 (1.07)	2.20 (1.62)	3.80 (2.07)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.20 (0.83)	2.26 (1.66)	4.66 (2.26)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.26 (0.87)	1.46 (1.39)	3.66 (2.03)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.06 (0.75)	1.20 (1.29)	4.06 (2.13)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.73 (1.10)	1.93 (1.55)	4.00 (2.11)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	1.20 (1.27)	3.66 (2.00)	5.20 (2.38)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.60 (1.01)	4.26 (2.17)	5.93 (2.53)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	1.00 (1.20)	4.40 (2.20)	5.80 (2.50)
T_{10}- Untreated control	2.20 (1.63)	5.20 (2.38)	6.40 (2.62)
SE ±	0.13	0.13	0.07
CD at 5 %	0.39	0.41	0.20

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

As compared to 25 DAS, the aphid population increased in all the treatments at 35 DAS after sowing (Table 6). All the treatments except the treatments of carbofuran 3 G @ 5 % seed treatment (T_8 and T_9) were superior over control. The lowest aphid population (3.66 aphids /leaf) was recorded in the treatment T_4 (thiamethoxam @ 4 g a.i./kg seed) followed by the treatments T_2, T_6, T_5 and T_1 which were at par with each other. These treatments were followed by the treatment T_3 (imidacloprid @ 10 g a.i./kg seed) and T_7 (Carbofuran 3 G @ 5 % seed treatment) which were at par with each other and recorded 4.66 and 5.20 aphids /leaf, respectively. The untreated control recorded the highest population i.e. 6.40 aphids/leaf.

4.2.1.1.2. Bioefficacy of seed dressers against aphids, *A. gossypii* during 2001-2002

During 2001-2002, as is evident from Table 7, all the treatments were significantly superior over control on 15 DAS in reducing aphid population. In the treatments of thiamethoxam @ 4 g a.i./kg seed (T_4 and T_6), no aphids were observed. These two treatments were at par with the treatments T_5 (thiamethoxam @ 4 g a.i. / kg seed), T_3 and T_2 (imidacloprid @ 10 g a.i./kg seed). It was followed by the treatments T_1 (imidacloprid @10 g a.i./kg seed) and T_7 and T_8 (carbofuran 3 G @ 5 % seed treatment). Among different treatments, the highest aphid population was recorded in the treatment T_9 (1.00 aphids /leaf).

Data on 25 DAS indicated that the least aphid population was recorded the treatment T_5 (1.66 aphids /leaf) followed by the treatment T_1, T_6 and T_4 which were at par with each other. The next effective treatments found were T_3 and T_2 (imidacloprid @ 10 g a.i. /kg seed). The least effective treatments were carbofuran 3 G @ 5 % seed treatment (T_7, T_8 and T_9).

At 35 DAS, all the treatments recorded lower aphid population than the control. The most effective treatment was T_6 (thiamethoxam @ 4 g a.i./kg seed) which recorded 3.53 aphids /leaf. All the treatments of imidacloprid @ 10 g a.i./kg seed (T_3, T_1 and T_2) and thiamethoxam @ 4 g a.i. /kg seed (T_6 , T_5 and T_4) were found at par with each other. Whereas the treatments of carbofuran 3 G @ 5 % seed treatment (T_9, T_7 and T_8) recorded the aphid population which was at par with the untreated control.

The highest aphid population (6.53 aphids /leaf) was recorded in the untreated control.

Table 7. Bioefficacy of seed dressers against aphids, *A. gossypii* during 2001-2002

Treatments	Number of aphids /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.40 (0.93)*	2.00 (1.57)	4.20 (2.16)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.33 (0.90)	2.86 (1.83)	4.40 (2.21)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.13 (0.79)	2.40 (1.70)	3.86 (2.08)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.00 (0.70)	2.20 (1.64)	4.26 (2.18)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.06 (0.75)	1.66 (1.46)	3.80 (2.06)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.00 (0.70)	2.06 (1.58)	3.53 (2.00)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.60 (1.04)	4.00 (2.11)	5.80 (2.50)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.66 (1.07)	4.60 (2.25)	6.00 (2.54)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	1.00 (1.21)	4.66 (2.26)	5.46 (2.44)
T_{10}- Untreated control	2.00 (1.57)	5.20 (2.38)	6.53 (2.65)
SE ±	0.06	0.07	0.07
CD at 5 %	0.20	0.23	0.22

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

4.2.1.1.3. Bioefficacy of seed dressers against aphids during 2000-2001 and 2001-2002 (pooled)

The pooled results for the year 2000-2001 (Table 8) indicated that all the treatments were significantly superior over control in reducing the aphid population.

The aphid population on 15 DAS ranged from 0.13 aphids /leaf to 2.10 aphids / leaf. The most effective treatments in controlling aphids were thiamethoxam @ 4 g a.i./kg seed (T_4, T_5 and T_6) followed by T_3 (imidacloprid @ 10 g a.i./kg seed) which were at par with each other.

Table 8. Bioefficacy of seed dressers against aphids (pooled), during 2000- 2001 and 2001-2002

Treatments	Number of aphids /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.60 (0.97)*	2.40 (1.62)	4.43 (2.19)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.53 (0.93)	2.53 (1.77)	4.10 (2.14)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.16 (0.79)	2.33 (1.69)	4.26 (2.17)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.13 (0.73)	1.83 (1.57)	3.96 (2.10)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.06 (0.75)	1.43 (1.41)	3.93 (2.09)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.36 (0.78)	1.99 (1.57)	3.76 (2.05)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.90 (1.08)	3.83 (2.08)	5.50 (2.44)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.63 (1.05)	4.43 (2.23)	5.96 (2.53)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	1.00 (1.20)	4.53 (2.24)	5.63 (2.47)
T_{10}- Untreated control	2.10 (1.58)	5.20 (2.38)	6.46 (2.63)
SE $\pm$	0.06	0.06	0.07
CD at 5 %	0.16	0.19	0.19

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

Among different treatments, the least effective treatments were of carbofuran 3 G @ 5 % seed treatment (T_8, T_7 and T_9). The untreated control recorded the highest number of (2.10) aphids /leaf.

The data collected on 25 DAS (Table 8) revealed that all the treatments were significantly superior over control in reducing the aphid population. The aphid population ranged between 1.43 to 5.20 aphids /leaf. The most effective treatments were of thiamethoxam @ 4 g a.i./kg seed treatment (T_5, T_4 and T_6), which were at par with each other. The next best treatments were of imidacloprid @ 10 g a.i./kg seed treatment (T_1, T_3 and T_2), which were at par with each other. The least effective treatments were of carbofuran 3 G @ 5 % seed treatment (T_7, T_8 and T_9). The untreated control recorded 5.20 aphids /leaf.

Aphid population on 35 DAS ranged from 3.76 to 6.46 aphids / leaf. All the treatments were significantly superior over control. All the treatments of thiamethoxam @ 4 g a.i./kg seed treatment (T_6, T_5 and T_4) and imidacloprid @ 10 g a.i./kg seed treatment (T_2 and T_3) were at par with each other. The least effective treatments were of carbofuran 3G @ 5 % seed treatment (T_7, T_9 and T_8). The untreated control recorded highest number of aphids (6.46 / leaf).

4.2.1.2. Bioefficacy of seed dressers against jassids (nymphs)

4.2.1.2.1. Bioefficacy of seed dressers against jassids, *A. biguttulla biguttulla* during 2000-2001

The data on jassid population during 2000-2001 (Table 9) indicated that the jassid population ranged between 0.00 /leaf to 0.73 jassids (nymph) /leaf on 15 DAS. All the treatments were significantly superior over control in reducing jassid population. The most effective treatments were T_4 and T_5 (thiamethoxam @ 4 g a.i./kg seed) which recorded no jassids. These treatments were followed by the treatment T_3 (imidacloprid @ 10 g a.i./kg seed). All these treatments were at par with each other. The rest of the treatments were intermediate and at par with each other. The untreated control recorded highest number of jassids (0.73 jassids/leaf).

The data on 25 DAS (Table 9) showed that all the treatments except the treatment T_7 (carbofuran 3 G @ 5% seed treatment) were superior over control. The lowest number of jassids (1.60 /leaf) was recorded in the treatment T_6 (thiamethoxam @ 4 g a.i./kg seed). All the treatments of thiamethoxam @ 4 g a.i./kg seed treatment and imidacloprid @ 10 g a.i./kg seed treatment were at par with each other. Among the different treatments, carbofuran 3 G @ 5 % seed treatments (T_7, T_8 and T_9) were found to be less effective in controlling jassid population on 25 DAS.

Table 9. Bioefficacy of seed dressers against jassid *A. biguttulla biguttulla* during 2000-2001

Treatment	Number of jassids /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.20 (0.83)*	2.93 (1.85)	4.53 (2.21)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.33 (0.91)	2.80 (1.80)	3.40 (1.97)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.13 (0.78)	2.13 (1.62)	3.06 (1.88)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.00 (0.70)	2.00 (1.55)	2.13 (1.59)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.00 (0.70)	2.73 (1.78)	2.73 (1.79)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.26 (0.87)	1.60 (1.41)	1.86 (1.53)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.26 (0.87)	3.80 (2.06)	4.60 (2.24)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.40 (0.94)	3.40 (1.97)	5.20 (2.38)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	0.40 (0.94)	3.40 (1.97)	5.20 (2.38)
T_{10}- Untreated control	0.73 (1.10)	5.06 (2.35)	8.06 (2.92)
SE ±	0.05	0.15	0.11
CD at 5 %	0.15	0.44	0.35

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

As compared to 25 DAS, the jassid population increased in all the treatments at 35 DAS (Table 9). The results further indicated that all the treatment were significantly superior over control in reducing the jassid population. The most effective treatment was T_6 (thiamethoxam @ 4 g a.i./kg seed) which recorded 1.86 jassids /leaf. This was followed by the treatment T_4, T_5 (thiamethoxam @ 4 g a.i./kg seed) and T_3 (imidacloprid @ 10 g a.i. /kg seed) which were at par with each other. The least effective treatment was T_9 (Carbofuran 3 G @ 5 % seed treatment) which recorded 5.20 jassids/leaf.

4.2.1.2.2. Bioefficacy of seed dressers against jassids (nymphs) during 2001-2002

The data from Table 10 indicated that the jassid population on 15 DAS ranged from 0.06 to 2.00 jassids/leaf. The carbofuran 3 G @ 5 % seed treatments (T_7, T_8 and T_9) were at par with the untreated control. The treatments of imidacloprid @ 10 g a.i./kg seed treatment (T_1, T_2 and T_3) and thiamethoxam @ 4 g a.i. /kg seed treatment (T_4, T_5 and T_6) showed no significant differences in controlling the jassid population and all were at par with each other.

At 25 DAS, significantly less population of jassid was observed in all the treatments than control. Treatment T_4 (thiamethoxam @ 4 g a.i./kg seed treatment) recorded the lowest population (1.66 jassids / leaf). It was at par with the treatments T_6 (thiamethoxam @ 4 g a.i./kg seed), T_2 (imidacloprid @ 10 g a.i./kg seed) and T_8 (carbofuran 3 G @ 5% seed treatment). The untreated control recorded 4.46 jassids /leaf.

It is evident from Table 9 that at 35 DAS, the population of jassid was significantly lower in all the treatments as compared to control. The treatments of thiamethoxam @ 4 g a.i./kg seed treatment (T_4, T_6 and T_5) were found most effective in controlling jassid population which were at par with the treatment T_1 (imidacloprid @ 10 g a.i. /kg seed). Among different treatments, carbofuran 3 G @ 5 % seed treatments (T_9 and T_7) recorded the highest jassid population of 6.20 and 6.46 jassids /leaf.

Table 10. Bioefficacy of seed dressers against jassid *A. biguttulla biguttulla* during 2001-2002

Treatment	Number of jassids (nymphs) /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.73 (1.10)*	2.60 (1.75)	3.53 (2.00)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.93 (1.19)	2.13 (1.62)	3.80 (2.06)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	1.00 (1.17)	2.80 (1.81)	4.13 (2.15)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.13 (0.78)	1.66 (1.46)	2.66 (1.76)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.06 (0.75)	2.88 (1.81)	3.40 (1.97)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.40 (0.94)	2.00 (1.58)	3.06 (1.87)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	1.26 (1.26)	3.00 (1.86)	6.46 (2.63)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	1.13 (1.26)	2.33 (1.68)	5.53 (2.44)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	1.80 (1.51)	3.40 (1.95)	6.20 (2.58)
T_{10}- Untreated control	2.00 (1.55)	4.46 (2.22)	9.20 (3.11)
SE ±	0.14	0.08	0.11
CD at 5 %	0.44	0.26	0.35

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

4.2.1.2.3. Bioefficacy of seed dressers against jassids (nymphs) during 2000-2001 and 2001-2002 (pooled)

The pooled results for the 2000-2001 and 2001-2002 (Table 11) revealed that all the treatments were significantly superior over control on 15, 25 and 35 DAS.

Table 11. Bioefficacy of seed dressers against jassid *A. biguttulla biguttulla* (pooled) during 2000-2001 and 2001-2002

Treatment	Number of jassids (nymphs) /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.46 (0.85)*	2.76 (1.77)	4.03 (2.10)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.63 (0.93)	2.46 (1.66)	3.60 (2.01)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.56 (0.82)	2.46 (1.76)	3.59 (2.01)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.06 (0.70)	1.83 (1.48)	2.39 (1.67)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.03 (0.70)	2.80 (1.80)	3.06 (1.88)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.33 (0.87)	1.80 (1.53)	2.46 (1.70)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.76 (0.91)	3.40 (1.91)	5.53 (2.43)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.76 (0.97)	2.73 (1.73)	5.13 (2.36)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	1.10 (1.00)	3.40 (1.95)	5.70 (2.48)
T_{10}- Untreated control	1.36 (1.14)	4.76 (2.25)	8.63 (3.01)
SE ±	0.04	0.07	0.05
CD at 5 %	0.13	0.21	0.14

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

Jassid population on 15 DAS ranged between 0.03 to 1.36 jassids /leaf. The most effective treatment was T_5 (thiamethoxam @ 4 g a.i./kg seed) which recorded 0.03 jassids /leaf. The least effective treatments were of carbofuran 3 G @ 5 % seed treatment (T_8 and T_9) which recorded 0.76 and 1.10 jassids /leaf, respectively.

The data on 25 DAS indicated that all the treatments were significantly superior over control. The most effective treatments were T_4

and T_6 (thiamethoxam @ 4 g a.i./kg seed) followed by T_2 (imidacloprid @ 10 g a.i./kg seed) which were at par with each other. The least effective treatment was T_9 (carbofuran 3 G @ 5 % seed treatment) which recorded 3.40 jassids/leaf. Rest of the treatments were intermediate and at par with each other.

It is evident from Table 11 that the jassid population increased in all the treatments on 35 DAS as compared to the population on 25 DAS. The jassid population in different treatments indicated similar results as on 25 DAS. The most effective treatments were T_4 and T_6 (thiamethoxam @ 4 g a.i./kg seed) which were at par with each other and the least effective treatments were carbofuran 3 G @ 5 % seed treatment (T_8, T_7 and T_9). The jassid population in imidacloprid @ 10 g a.i./kg seed treatments (T_1, T_2 and T_3) stood intermediate and was at par with each other.

4.2.1.3. Bioefficacy of seed dressers against whitefly

4.2.1.3.1 Bioefficacy of seed dressers against whitefly during 2000-2001

The data on whitefly (adult) population during 2000-2001 (Table 12) indicated that the population ranged between 0.13 to 1.60 whiteflies/leaf on 15 DAS. All the treatments were significantly superior over control in reducing whitefly population. The most effective treatments were of thiamethoxam @ 4 g a.i./kg seed (T_6, T_4 and T_2) and imidacloprid @ 10 g a.i./kg seed (T_1 and T_2). All these treatments were at par with each other.

Among different seed treatments, the least effective treatments were of carbofuran 3 G @ 5% seed treatment (T_9 and T_8) which were at par with each other. The untreated control recorded highest population (1.60/leaf) of whiteflies.

Table 12. **Bioefficacy of seed dressers against whitefly, *B. tabaci* during 2000-2001**

Treatment	Number of whitefly /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.40 (0.94)*	1.46 (1.39)	1.33 (1.35)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.40 (0.94)	1.00 (1.20)	1.60 (1.44)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.53 (1.01)	1.33 (1.34)	1.26 (1.32)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.20 (0.83)	0.73 (1.34)	1.40 (1.37)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.26 (0.87)	1.00 (1.20)	1.13 (1.27)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.13 (0.79)	0.80 (1.13)	1.20 (1.27)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.73 (1.10)	1.86 (1.53)	1.73 (1.47)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	1.13 (1.27)	2.06 (1.59)	2.40 (1.70)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	1.00 (1.22)	1.60 (1.44)	1.53 (1.42)
T_{10}- Untreated control	1.60 (1.44)	2.80 (1.81)	3.06 (1.88)
SE ±	0.06	0.11	0.11
CD at 5 %	0.18	0.33	0.33

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

The observation on the 25 DAS revealed that all the treatments were significantly superior over control. The lowest whitefly population (0.73/leaf) was recorded in T_4 (thiamethoxam @ 4 g a.i./kg seed). All the treatments of imidacloprid @ 10 g a.i./kg seed (T_1, T_2 and T_3) and thiamethoxam @ 4 g a.i./kg seed (T_4, T_5 and T_6) were at par with each other. The least effective treatments were of carbofuran 3 G @ 5% seed treatment (T_9, T_8 and T_7) and were at par with each other.

The data on whitefly population at 35 DAS indicated that the population was slightly increased when compared to 25 DAS. All the treatments except carbofuran 3G @ 5% seed treatment (T_8) were superior over control. Rest all the treatments were at par with each other.

4.2.1.3.2 Bioefficacy of seed dressers against whitefly during 2001-2002

The observations on whitefly population during the summer season of 2001-2002 are presented in Table 13.

Table 13. Bioefficacy of seed dressers against whitefly, *B. tabaci* during 2001-2002

Treatment	Number of whitefly /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.20 (0.83)*	0.53 (1.01)	1.20 (1.30)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.13 (0.78)	0.40 (0.93)	1.26 (1.32)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.13 (0.79)	0.66 (1.07)	1.00 (1.21)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.00 (0.70)	0.20 (0.83)	0.93 (1.19)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.06 (0.75)	0.40 (0.94)	0.66 (1.07)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.20 (0.83)	0.06 (0.75)	0.80 (1.13)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.66 (1.07)	0.80 (1.13)	1.40 (1.36)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.40 (0.94)	1.00 (1.20)	1.33 (1.34)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	0.53 (1.00)	0.80 (1.13)	1.00 (1.09)
T_{10}- Untreated control	0.86 (1.16)	1.40 (1.36)	2.13 (1.61)
SE ±	0.06	0.08	0.09
CD at 5 %	0.18	0.26	0.27

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

The data on 15 DAS indicated that all the treatments were significantly superior over control in reducing the whitefly population. All the treatments of thiamethoxam @ 4 g a.i./kg seed (T_4, T_5 and T_6) and imidacloprid @ 10 g a.i./kg seed (T_2, T_3 and T_1) were at par with each other. The next effective treatments were of carbofuran 3 G @ 5% seed treatment (T_8, T_9 and T_7) and were at par with each other. The untreated control recorded the higher number (0.86) whiteflies/leaf.

When compared to 15 DAS, the whitefly population on 25 DAS increased slightly and ranged from 0.06 to 1.40 whiteflies/leaf. All the treatments showed significant differences with control. The least whitefly population (0.06 /leaf) was recorded in the treatment of T_6 (thiamethoxam @ 4 g a.i. /kg seed). .It was followed by the treatments T_4, T_2, T_5 and T_1 which were at par with each other. Among different treatments, carbofuran 3 G @ 5 % seed treatments, (T_8) recorded the highest number (1.00 /leaf) of whiteflies.

The observations on 35 DAS indicated that all the treatments except T_8 (carbofuran 3 G @ 5 % seed treatment) were superior over control in reducing whitefly population. Rest of the treatments were at par with each other. The overall whitefly population ranged between 0.66 to 2.13 whiteflies /leaf.

4.2.1.3.3. Bioefficacy of seed dressers against whitefly during 2000-2001 and 2001-2002 (Pooled)

The pooled results for the year 2000-2001 and 2001-2002 (Table 14) indicated that all the treatments were significantly superior over control in reducing the whitefly population. The per leaf whitefly population at 15 DAS ranged from 0.10 to 1.23. The most effective treatments in controlling the whitefly were of thiamethoxam @ 4 g a.i. /kg seed (T_4, T_5 and T_6) and imidacloprid @ 10 g a.i./kg seed (T_1). All these treatments were at par with each other.

Table 14. Bioefficacy of seed dressers against whitefly, *B. tabaci* (pooled) during 2000-2001 and 2001-2002

Treatment	Number of whitefly /leaf		
	15 DAS	25 DAS	35 DAS
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.30 (0.88)	0.99 (1.20)	1.26 (1.32)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.26 (0.86)	0.70 (1.06)	1.43 (1.38)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.33 (0.90)	0.99 (1.20)	1.13 (1.26)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.10 (0.76)	0.46 (0.96)	1.16 (1.28)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.16 (0.81)	0.70 (1.07)	0.89 (1.17)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	0.16 (0.81)	0.43 (0.94)	1.00 (1.20)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	0.69 (1.08)	1.33 (1.33)	1.56 (1.41)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.76 (1.10)	1.53 (1.39)	1.86 (1.52)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	0.76 (1.11)	1.20 (1.28)	1.26 (1.25)
T_{10}- Untreated control	1.23 (1.30)	2.10 (1.58)	2.59 (1.74)
SE ±	0.04	0.06	0.06
CD at 5 %	0.11	0.17	0.18

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

The data collected on 25 DAS revealed that all the treatments had significant differences with control. The least number of whiteflies were recorded in the treatments of thiamethoxam @ 4 g a.i./kg seed (T_6, T_4 and T_5) and imidacloprid @ 10 g a.i./kg seed (T_2) and were at par with each other. Among different treatments, carbofuran 3 G @ 5 % seed treatment (T_8) recorded the highest (1.53 / leaf) population of whiteflies. The untreated control recorded the highest number (2.10) of whiteflies /leaf.

The whitefly population at 35 DAS ranged from 0.89 to 2.59 whiteflies /leaf. The lowest whitefly population (0.89 /leaf) was recorded in T_5 (thiamethoxam @ 4 g a.i./kg seed). The treatment T_8 (carbofuran 3 G @ 5 % seed treatment) recorded the highest number (1.86/leaf) of whitefly.

4.2.2. Efficacy of different insecticides against *E. vittella* fruit infestation (on weight basis)

The data regarding per cent fruit infestation by *E. vittella* on weight basis for the year 2000-2001, 2001-2002 and pooled results are presented in Table 15.

During 2000-2001, the fruit infestation ranged from 7.08 to 38.36 per cent and all the treatments were significantly superior over control. The most effective treatments were profenophos + cypermethrin 44 EC @ 1000 ml/ha (T_2, T_8 and T_5) which recorded 7.08 %, 8.62 % and 9.58 % fruit infestation respectively and all these treatments were at par with each other. These were followed by the treatments of spinosad 48 SC @ 750 ml /ha (T_7, T_4 and T_1) which were at par with the treatments of monocrotophos 36 EC @ 750 ml/ha (T_6 and T_7).

During 2001-2002, the fruit infestation was in the range of 6.30 to 37.69 per cent and all the treatments were significantly superior over control in reducing the fruit infestation. Minimum fruit infestation (6.30 %) was recorded in the treatment **T_2** (profenophas + cypermethrin 44 EC @ 1000 ml/ha). It was closely followed by the treatments of spinosad 48 SC @ 750 ml /ha (T_4, T_7 and T_1) and all these treatments were at par with each other. Among different insecticidal treatments comparatively more fruit infestation (14.94, 15.87, 19.13 % respectively) was recorded in the treatments of monocrotophos 36 EC @ 750 ml/ha (T_6, T_3 and T_9) which were at par with each other.

Table 15. Bioefficacy of different insecticides against *E. vittella* fruit infestation (on weight basis) for the years 2000-2001 and 2001-2002 and pooled

Treatment	Per cent fruit infestation		
	2000-2001	2001-2002	Pooled
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	14.45 (22.31)*	10.62 (18.97)	12.53 (20.64)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	7.08 (15.42)	6.30 (14.45)	6.69 (14.93)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	18.35 (25.34)	15.87 (23.46)	17.11 (24.40)
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	14.27 (22.04)	9.91 (18.31)	12.09 (20.17)
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	9.58 (18.00)	7.10 (15.39)	8.34 (16.69)
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	16.31 (23.76)	14.94 (22.68)	15.62 (23.21)
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	13.55 (21.58)	10.43 (18.77)	11.99 (20.17)
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	8.62 (17.06)	9.70 (17.95)	9.16 (17.50)
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	16.36 (23.82)	19.13 (25.91)	17.74 (24.86)
T_{10}- Untreated control	38.36 (38.19)	37.69 (37.85)	38.02 (38.02)
SE ±	1.07	1.17	0.75
CD at 5 %	3.19	3.49	2.08

* - Figures in parentheses are angular transformed values.

The pooled data (Table 15) for the years 2000-2001 and 2001-2002 indicated that the fruit infestation ranged from 6.69 to 38.02 per cent. All the treatments were found to be significant over control in reducing fruit infestation. Minimum fruit infestation was observed in the treatments of profenophos + cypermethrin 44 EC @ 1000 ml/ha (6.69 and 8.34 per cent in T_2 and T_5, respectively) which were at par with each other. It was closely followed by the treatment T_8 recording 9.16 % fruit

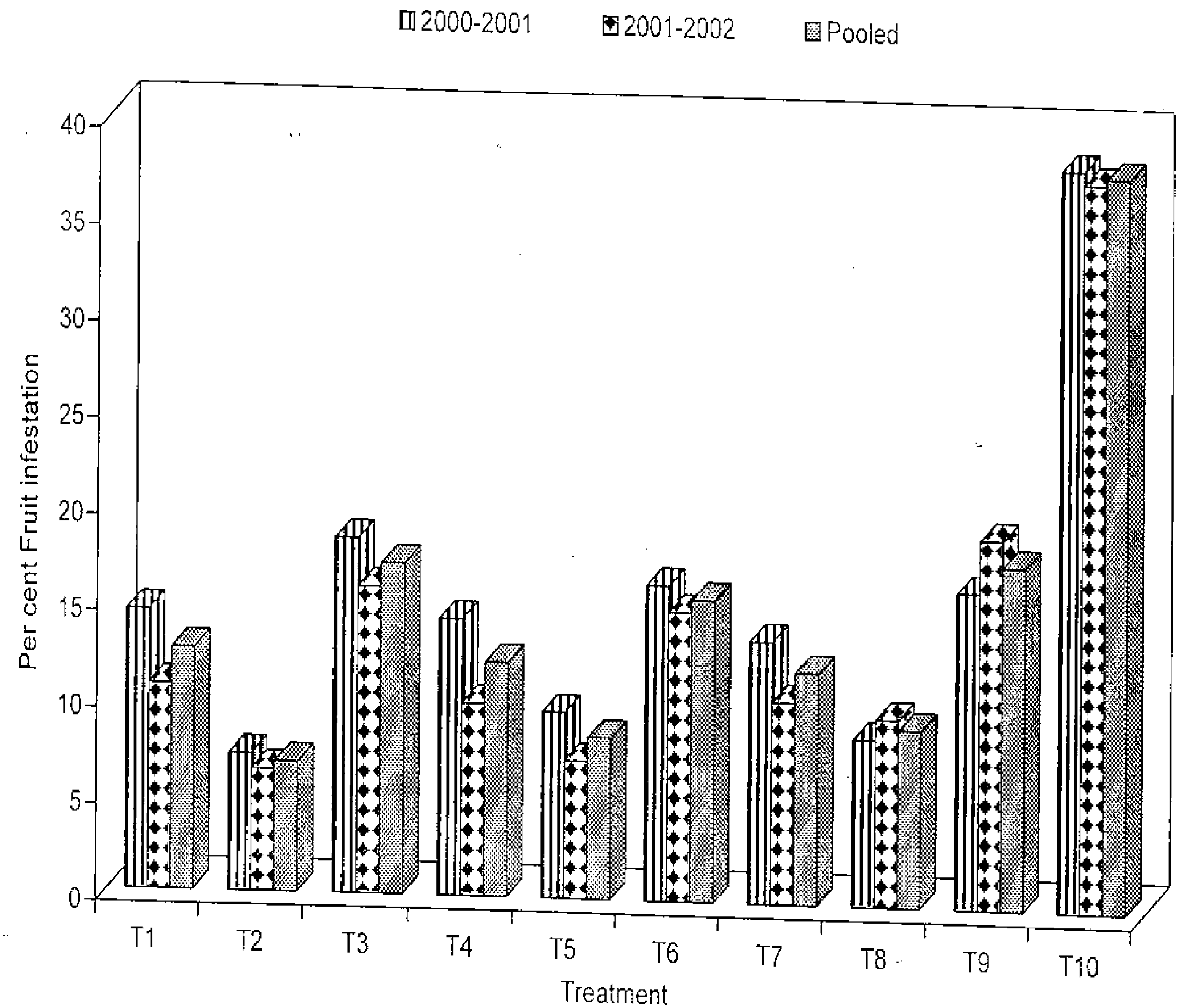


Fig. 8. Bioefficacy of different insecticides against *E. vittella* fruit infestation (on weight basis)

infestation. The next best treatments in reducing fruit infestation were of spinosad 48 SC @ 750 ml/ha (T_7, T_4 and T_1) which recorded 11.99, 12.09 and 12.53 % fruit infestation respectively and were at par with each other. Among different insecticidal treatments, the least effective treatments were monocrotophos 36 EC @ 750 ml/ha (T_6, T_3 and T_9) which recorded 15.62, 17.11 and 17.74 % fruit infestation, respectively and all these were at par with each other.

4.3. Effect of different insecticidal treatments on marketable fruit yield of okra

The data on marketable fruit yield of okra for the years 2000-2001, 2001-2002 and pooled results are presented in Table 16 and Fig. 9. The results indicated that all the treatments were significantly superior over control in both the years and in pooled results.

4.3.1. During 2000-2001

During 2000-2001, the marketable fruit yield ranged from 52.21 to 82.33 q/ha. Highest yield (82.23 q/ha) was recorded in the treatment T_5 (thiamethoxam @ 4 g a.i./kg seed followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha). The next best treatments were imidacloprid @ 10 g a.i. /kg seed alternated with (profenophos + cypermethrin 44 EC @ 1000 ml/ha) (80.71 q/ha), thiamethoxam @ 4 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha) (76.10 q/ha), and imidacloprid @ 10 g a.i. /kg seed alternated with spinosad 48 SC @ 750 ml/ha) (75.90 q/ha). All these treatments were at par with each other. Among different treatments, the lowest fruit yield was recorded in the treatment of carbofuran 3 G @ 5 % seed treatment followed by monocrotophos 36 EC @ 750 ml/ha (63.33 q/ha).

A : Egg of *Earias vittella*

B : Fruit damage by *Earias vittella* larva

C : Larva of *Earias vittella*

Plate : 2

Table 16. Effect of different insecticidal treatments on marketable fruit yield of okra

Treatment	Marketable fruit yield (q/ha)		
	2000-2001	2001-2002	Pooled
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	75.90	77.19	76.54
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	80.71	82.70	81.70
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	68.66	72.30	70.48
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	76.10	77.50	76.80
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	82.23	84.32	83.27
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	67.78	71.85	69.81
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	68.13	73.00	70.56
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	70.60	75.20	72.90
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	63.33	65.24	64.28
T_{10}- Untreated control	52.21	48.60	50.40
SE ±	1.68	1.78	1.14
CD at 5 %	4.98	5.30	3.15

4.3.2. During 2001-2002

During 2001-2002, the fruit yield ranged from 48.60 to 84.32 q/ha. The highest yield was recorded in the treatment of thiamethoxam @ 4 g a.i./kg seed alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha (84.32 q/ha). It was at par with treatment imidacloprid @ 10 g a.i./kg seed alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha by recording 82.70 q/ha yield. The next best treatments in respect of fruit yield were thiamethoxam @ 4 g a.i. /kg seed alternated with spinosad 48 SC @ 750 ml/ha (77.19 q/ha) and these two treatments were at par with each

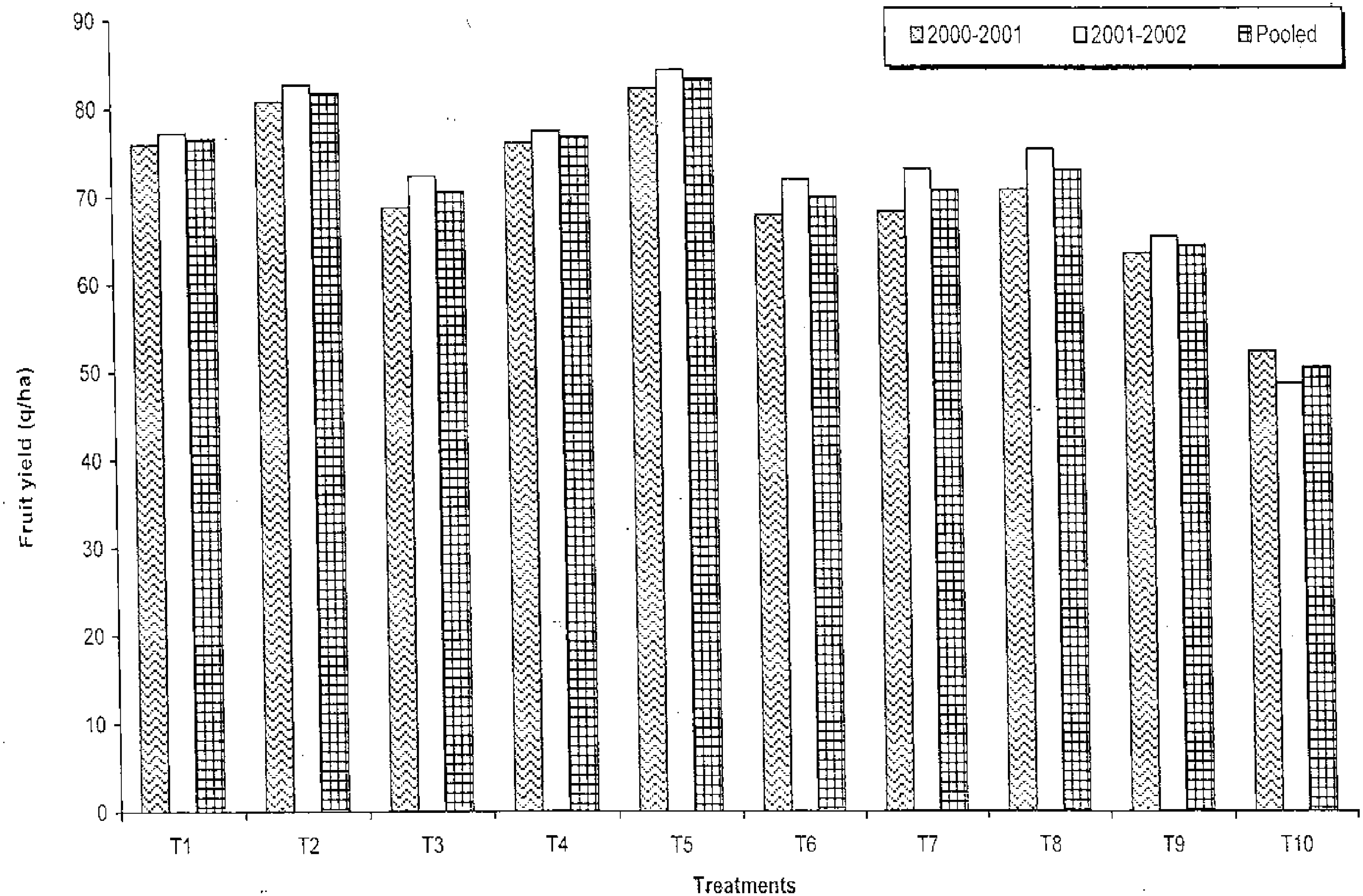


Fig. 9. Effect of different insecticidal treatments on marketable fruit yield of okra

other. Among different insecticidal treatments, comparatively lowest yield (65.24 q/ha) was recorded in the treatment of carbofuran 3 G @ 5 % seed treatment alternated with monocrotophos 36 EC @ 750 ml/ha.

4.3.3. During 2000-2001 and 2001-2002 (pooled)

Pooled data for the years 2000-2001 and 2001-2002 (Table 16) indicated that all the treatments were significantly superior over control. The average marketable fruit yield among different treatments ranged from 50.40 to 83.27 q/ha. The highest yield was recorded in the treatment of thiamethoxam @ 4 g a.i./kg seed alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha (83.27 q/ha) which was at par with imidacloprid @ 10 g a.i./kg seed alternated with profenophos + cypermethrin 44 EC @ 1000 ml /ha (81.70 q/ha). It was followed by thiamethoxam @ 4 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha (76.80 q/ha) and imidacloprid @ 10 g a.i./kg seed alternated with profenophos + cypermethrin 44 EC @ 750 ml/ha (76.54 q/ha) and these were at par with each other. Among different insecticidal treatments, the lowest yield (64.28 q/ha) was recorded in the treatment of carbofuran 3 G @ 5 % seed treatment alternated with monocrotophos 36 EC @ 750 ml/ha. Rest of the treatments were intermediate and at par with each other.

4.4. To study the economics of various treatment application in okra pest management

The data on the economics of the various treatment applications are given in Table 17, 18 and 19.

4.4.1. During 2000-2001

It is evident from Table 17 that during summer 2000-2001, the net returns (Rs/ha) offered through different treatments ranged from -12627 to 20376. The highest net returns of Rs. 20,376 /ha was achieved in the treatment of thiamethoxam @ 4 g a.i./kg seed treatment followed by

Table 17. Economics of various treatment application during 2000-2001

Treatment	Yield (q/ha)	Marginal cost (Rs.)	Marginal product (q/ha)	Marginal returns (Rs)	Net returns (Rs)	Cost benefit ratio
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	75.90	26930	23.69	18952	-7978	1:0.7037
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	80.71	3980	28.50	22800	18820	1:5.72
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	68.66	3260	16.45	13160	9900	1:4.03
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	76.10	26590	23.89	19112	-7478	1:0.7187
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	82.23	3640	30.02	24016	20376	1:6.59
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	67.78	2920	15.57	12456	9536	1:4.26
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	68.13	25363	15.92	12736	-12627	1:0.5021
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	70.60	2413	18.39	14712	12299	1:6.09
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	63.33	1693	16.12	12896	11203	1:7.61
T_{10}- Untreated control	52.21	---	---	---	---	---

profenophos + cypermethrin 44 EC @ 1000 ml/ha. It was followed by the imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which reported the net profit of Rs. 18820 /ha. The treatment of carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha and carbofuran 3 G @ 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/na also recorded good net returns of Rs. 12299 and Rs. 11203/ha.

The treatments imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha, thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha and carbofuran 3 G @ 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha recorded a loss of Rs. 7978, Rs. 7478 and Rs. 12627/ha respectively.

The cost benefit ratio (CBR) obtained through different treatments ranged from 1:0.50 to 1:7.61. Though the highest marketable fruit yield (82.23 q/ha) was recorded by the treatment of thiamethoxam @ 4 g a.i. /kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml /ha (with a CBR of 1:6.59), the highest cost benefit ratio (1:7.61) recorded by the treatment comprising carbofuran 3 G @ 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha. This was due to the low cost of insecticides. The treatments carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha and imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha also recorded a good CBR of 1:6.09 and 1:5.72, respectively. The lowest CBR of 1:0.50 was recorded by the treatment of carbofuran 3 G @ 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.

Table 18. Economics of various treatment application during 2001-2002

Treatment	Yield (q/ha)	Marginal cost (Rs.)	Marginal product (q/ha)	Marginal returns (Rs)	Net returns (Rs)	Cost benefit ratio
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	77.19	26930	28.59	22872	-4058	1:0.8493
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	82.70	3980	34.10	27280	23300	1:5.85
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	72.30	3260	23.70	18960	15700	1:5.81
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	77.50	26590	28.90	23120	-3470	1:0.8694
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	84.32	3640	35.72	28576	24936	1:7.85
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	71.85	2920	23.25	18600	15680	1:5.36
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	73.00	25363	24.40	19520	-5843	1:0.7696
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	75.20	2413	26.6	21280	18867	1:8.81
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	65.24	1693	16.64	13312	11619	1:7.86
T_{10}- Untreated control	48.60	---	---	---	---	---

4.4.2. During 2001-2002

Same trend was observed during the year 2001-2002 (Table 18). The net returns (Rs/ha) through various treatment application ranged from -5843 to 24936. The highest net return was achieved with thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha (Rs. 24936 /ha). It was followed by the treatment imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha and carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which recorded Rs. 23300 and Rs. 18867 /ha net returns, respectively, whereas the treatments thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha, imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha and carbofuran 3 G @ 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha recorded the net loss of Rs. 3470, Rs. 4058 and Rs. 5843 /ha, respectively.

The CBR in various treatments ranged from 1:0.76 to 1:8.81. The highest CBR of 1:8.81 was observed in the treatment of carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. It was followed by carbofuran 3 G @ 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha (CBR - 1:7.86) and thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which recorded a CBR of 1:7.85.

4.4.3. During 2000-2001 and 2001-2002 (Pooled)

From the pooled data (Table 19), it is evident that the highest net returns of Rs. 22656 /ha was achieved through thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml / ha. It was followed by treatment of imidacloprid @ 10 g a.i. /kg

Table 19. Economics of various treatment application during 2000-2001 and 2001-2002 (pooled)

Treatment	Yield (q/ha)	Marginal cost (Rs.)	Marginal product (q/ha)	Marginal returns (Rs)	Net returns (Rs)	Cost benefit ratio
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	76.54	26930	26.14	20912	-6018	1:0.7765
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	81.70	3980	31.30	25040	21060	1:6.29
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	70.48	3260	20.08	16064	12804	1:4.92
T_4- Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	76.80	26590	26.40	21120	-5470	1:0.79
T_5- Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	83.27	3640	32.87	26296	22656	1:7.22
T_6- Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	69.81	2920	19.41	15528	12608	1:5.31
T_7- Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	70.56	25363	20.16	16128	-9235	1:0.6358
T_8- Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	72.90	2413	22.50	18000	15587	1:7.45
T_9- Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	64.28	1693	13.88	11104	9411	1:6.55
T_{10}- Untreated control	50.40	---	---	---	---	---

seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which recorded net returns of Rs. 21060 /ha.

The treatments comprising carbofuran 3 G @ 5 % seed treatment followed spinosad 48 SC @ 750 ml/ha, imidacloprid @ 10 g a.i. /kg seed treatment followed by spinosad 48 SC @ 750 ml/ha and thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha recorded the net loss of Rs. 9235, Rs. 6018 and Rs. 5470 /ha.

The cost benefit ratio (CBR) in various treatments ranged from 1:0.63 to 1:7.45. The highest CBR (1:7.45) was observed in the treatment of carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. It was followed by thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha (1:7.22) and carbofuran 3 G @ 5% seed treatment followed by monocrotophos 36 SL @ 750 ml/has (1:6.55). The least CBR of 1:0.63 was achieved by the treatment of carbofuran 3 G @ 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.

4.5. Effect of different insecticidal treatment on larval parasitization of *E. vittella*

The data regarding per cent larval parasitization of *E. vittella* for both the years and pooled results indicated that no significant difference was observed among various treatmentsadministered (Table 20 and Fig. 10).

4.5.1. During 2000-2001

The observations during 2000-2001 indicated that the overall parasitization ranged between 0.00 to 5.33 %. The highest parasitization (5.33 per cent) was recorded in the untreated control. The next best treatment was imidacloprid 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha which recorded 2.66 per cent parasitization. It was followed by the treatments imidacloprid @ 4 g a.i./kg seed treatment alternated with monocrotophos 36 SL @ 750 ml/ha, thiamethoxam @ 4 g a.i./kg seed treatment alternated with spinosad 48 SC @ 750 ml/ha and carbofuran 3 G @ 5 % seed treatment alternated with spinosad 48 SC @ 750 ml/ha, all of which recorded 2.00 per cent parasitization. Though there was difference in per cent larval parasitization, all the treatments showed non-significant differences and were comparable with the untreated control.

Table 20. Effect of different insecticides treatments on larval parasitization of *E. vittella*

Treatment	Per cent larval parasitization		
	2000-2001	2001-2002	Pooled
T_1 - Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	2.66 (7.43)*	1.33 (5.41)	1.99 (6.42)
T_2 - Imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_3 - Imidacloprid @10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha	2.00 (6.55)	1.33 (5.41)	1.66 (5.98)
T_4 - Thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha.	2.00 (6.55)	2.66 (7.43)	2.33 (6.90)
T_5 - Thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	1.33 (5.41)	0.00 (0.00)	0.66 (2.70)
T_6 - Thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750ml/ha.	1.33 (5.41)	0.66 (2.70)	1.33 (5.41)
T_7 - Carbofuran 3 G 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha.	2.00 (6.55)	2.00 (6.55)	1.66 (5.98)
T_8 - Carbofuran 3 G 5 % seed treatment followed by profenophos +cypermethrin 44 EC @ 1000 ml/ha	0.66 (2.70)	0.00 (0.00)	0.33 (1.35)
T_9 - Carbofuran 3 G 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha.	1.33 (5.41)	0.66 (2.70)	0.99 (4.05)
T_{10} - Untreated control	5.33 (13.29)	3.33 (10.40)	4.33 (11.84)
SE ±	2.60	1.81	1.47
CD at 5 %	NS	NS	NS

* - Figures in parentheses are angular transformed values.

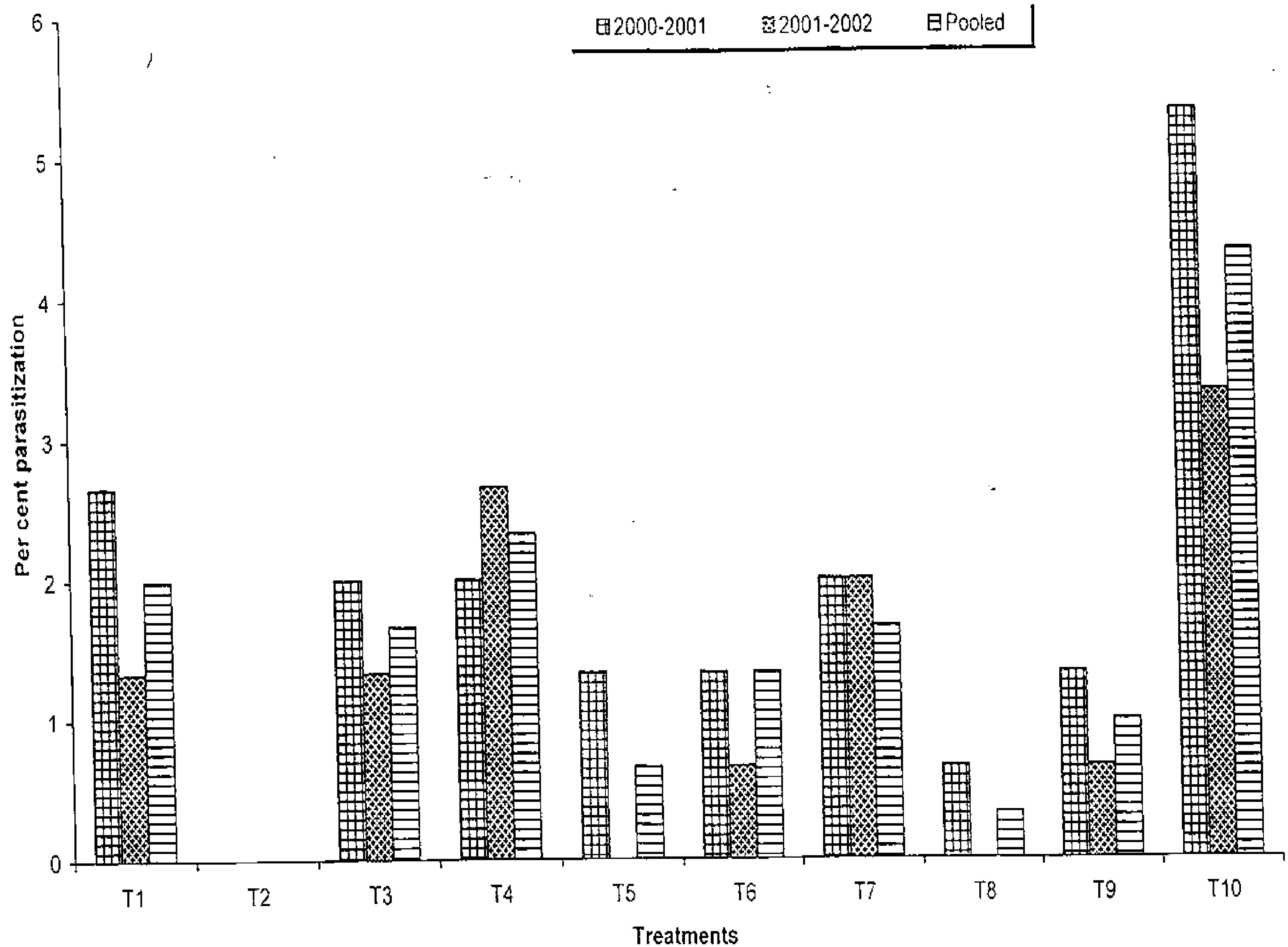


Fig. 10. Effect of different insecticidal treatments on larval parasitization of *E. vittella*.

The next best treatments were thiamethoxam @ 4 g a.i. /kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha, thiamethoxam @ 4 g a.i./kg seed treatment alternated with monocrotophos 36 SL @ 750 ml/ha and carbofuran 3G @ 5 % seed treatment alternated with monocrotophos 36 SL @ 750 ml/ha recorded 1.33 per cent parasitization. Whereas, the treatments carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which recorded 0.66 % parasitization and the treatment imidacloprid @ 10 g a.i./kg seed followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha in which no parasitization was observed. But as the results were non-significant therefore all the treatments were at par with each other regarding their effect on the parasitization of *E. vittella*.

4.5.2. During 2001-2002

As compared to 2000-2001, very less parasitization was observed during 2001-2002 ranging from 0.00 to 3.33 per cent. No significant differences were observed in various treatments. Highest parasitization (3.33 %) was observed in untreated control. Among various treatments, the highest parasitization was observed in thiamethoxam @ 4 g a.i./kg seed treatment alternated with spinosad 48 SC @ 750 ml/ha which recorded 2.66 per cent parasitization. It was followed by the treatments carbofuran 3 G @ 5 % seed treatment alternated with spinosad 48 SC @ 750 ml /ha (2.00 per cent), imidacloprid 10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750 ml/ha (1.33 %) and imidacloprid 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha (1.33%). The treatments thiamethoxam @ 4 g a.i./kg seed treatment alternated with monocrotophos 36 SL @ 750 ml/ha and carbofuran 3 G @ 5 % seed treatment alternated with monocrotophos 36 SL @ @ 750 ml/ha recorded 0.66 % parasitization each. Whereas, no parasitization was noticed in the treatments of imidacloprid @ 10 g a.i./kg seed treatment alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha, thiamethoxam @ 4 g a.i./kg seed treatment alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha and carbofuran 3 G @ 5 % seed treatment alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha. During this year also non-significant differences in per cent parasitization were observed.

4.5.3. During 2000-2001 and 2001-2002 (Pooled)

The pooled data for the year 2000-2001 and 2001-2002 revealed that the average parasitization ranged between 0.00 to 4.33 per cent. No significant differences were observed among various treatments. Highest parasitization (4.33 %) was observed in untreated control. It was followed by the treatments thiamethoxam @ 4 g a.i./kg seed treatment alternated with spinosad 48 SC @ 750 ml/ha and imidacloprid @ 10 g a.i./kg seed treatment alternated with spinosad 48 SC @ 750 ml/ha which recorded 2.33 and 1.99 % parasitization, respectively. The next best treatments to the parasitoid were of imidacloprid @ 10 g a.i./kg seed treatment alternated with monocrotophos 36 SL @ 750 ml/ha and carbofuran 3 G @ 5 % seed treatment alternated with spinosad 48 SC @ 750 ml/ha which reported 1.66 % parasitization each.

The treatments thiamethoxam @ 4 g a.i./kg seed treatment alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha and carbofuran 3 G @ 5 % seed treatment alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha recorded 0.66 and 0.33 per cent parasitization. Whereas no parasitization was observed in the treatment of imidacloprid @ 10 g a.i./kg seed treatment alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha. Thus the pooled results also brought out non-significant differences in larval parasitization among various treatments and were comparable with the untreated control. The parasitoids observed during both the years of study were *R. aligharensis* and *Bracon* spp.

4.6. Crop loss assessment due to key pests during various growth periods of okra

4.6.1. Incidence of aphids, *A. gossypii*

It is evident from Table 21 that significant differences were observed in various treatments during 2000-2001. The lowest aphid population (2.56 aphids/leaf) was recorded in the treatment T_3 (throughout protection). It is followed by treatment T_1 (protection during vegetative period only) which recorded 3.13 aphids /leaf and it was at par with the treatments T_2 (protection during reproductive period) which recorded 6.20 aphids /leaf.

Table 21. Incidence of aphid, *A. gossypii*

Treatment	Number of aphids / leaf		
	2000-2001	2001-2002	Pooled
T_1 -Protection during vegetative stage only	3.13 (1.90)*	4.26 (2.17)	3.69 (2.03)
T_2 - Protection during reproductive stage only	6.20 (2.58)	7.60 (2.84)	6.90 (2.71)
T_3 - Protection throughout growth period	2.56 (1.73)	2.20 (1.64)	2.38 (1.68)
T_4 -Untreated throughout growth period	8.64 (3.02)	7.92 (2.89)	8.28 (2.95)
SE ±	0.06	0.07	0.04
CD at 5 %	0.20	0.21	0.13

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

During 2001-2002, the lowest aphid population (2.20 /leaf) was recorded in the treatment T_3 (throughout protection) followed by treatment T_1 (protection during vegetative period) which recorded 4.26 aphids /leaf. The untreated control recorded 7.92 aphids /leaf.

The pooled results showed that the treatment T_3 (throughout protection) recorded the lowest aphid population (2.38 aphids/leaf). It was followed by treatment receiving protection during vegetative period only (3.69 aphids /leaf) and the treatments of protection during reproductive period only (6.90 aphids/leaf). The highest aphid population (8.28 aphids/leaf) was recorded in untreated control.

4.6.2. Incidence of jassids, *A. biguttulla biguttulla*

During 2000-2001, significant differences were observed in various treatments (Table 22). The lowest jassid population (3.68 jassids/leaf) was recorded in the treatment T_3 (throughout protection) followed by T_1 (protection during vegetative period) which recorded 5.20 jassids /leaf. Highest jassid population (9.44 jassids /leaf) was recorded in the untreated control.

Table 22. Incidence of jassids

Treatment	Number of jassids / leaf		
	2000-2001	2001-2002	Pooled
T_1 -Protection during vegetative stage only	5.20 (2.38)	3.88 (2.09)	4.54 (2.23)
T_2 - Protection during reproductive stage only	7.32 (2.79)	8.08 (2.92)	7.70 (2.85)
T_3 - Protection throughout growth period	3.68 (2.03)	4.40 (2.21)	4.04 (2.12)
T_4 -Untreated throughout growth period	9.44 (3.15)	8.60 (3.01)	9.02 (3.08)
SE ±	0.05	0.04	0.11
CD at 5 %	0.18	0.14	0.31

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

During 2001-2002, jassid population ranged between 3.88 to 8.60 jassids /leaf. The lowest population (3.88 jassids/leaf) was recorded in the treatment of protection during vegetative period followed by the

A : Pupa of *Earias vittella*

B : Mating adults of *Earias vittella*

Plate : 3

treatment of throughout protection (4.40 jassids/leaf). These treatments were at par with each other. The untreated control recorded 8.60 jassids/leaf.

The pooled data also represents similar trend as observed in 2001-2002. Numerically lowest jassid population (4.04/leaf) was recorded in the treatment of throughout protection which was at par with the treatment of protection during vegetative period (4.54 jassids/leaf). The highest jassid population was recorded in the untreated control (9.02 jassids/leaf) which was at par with the treatment of protection during reproductive period (7.70 jassid/leaf).

4.6.3. Incidence of whitefly

It is evident from Table 23 that during 2000-2001, the lowest whitefly population (0.96 /leaf) was recorded in the treatment of throughout protection which was at par with the treatment of protection during vegetative period (1.08 whiteflies/leaf). The whitefly population in the treatment of protection during reproductive period (2.04 /leaf) and untreated control (2.20 /leaf) were at par with each other.

Similar trend was observed during 2001-2002. But here the lowest whitefly population was recorded in the treatment of protection during vegetative period (1.00 whiteflies/leaf). The untreated control recorded highest (2.06 whiteflies /leaf) population.

The pooled data indicated that the whitefly population ranged from 1.04 to 2.14 whiteflies /leaf in different treatments. The lowest population was recorded in the treatment of protection during vegetative period (1.04 /leaf) which was at par with the treatment of throughout protection (1.06/leaf). The treatment of protection during reproductive period and untreated control recorded 2.20 and 2.14 whiteflies /leaf and were at par with each other.

Table 23. Incidence of whitefly

Treatment	Number of whiteflies / leaf		
	2000-2001	2001-2002	Pooled
T_1 -Protection during vegetative stage only	1.08 (1.25)	1.00 (1.21)	1.04 (1.23)
T_2 - Protection during reproductive stage only	2.04 (1.59)	2.36 (1.68)	2.20 (1.63)
T_3 - Protection throughout growth period	0.96 (1.20)	1.16 (1.28)	1.06 (1.24)
T_4 -Untreated throughout growth period	2.20 (1.64)	2.08 (1.60)	2.14 (1.62)
SE ±	0.04	0.03	0.08
CD at 5 %	0.14	0.12	0.23

* - Figures in parentheses are $\sqrt{x + 0.5}$ transformed values

4.6.4. Infestation of fruit borer

The data pertaining to the fruit borer infestation recorded during the course of investigation are presented in Table 24 and Fig. 11. The results obtained were significant during both the years and in respect of pooled results.

During 2000-2001, the percentage fruit infestation ranged between 13.52 to 37.76 per cent. The lowest fruit infestation was recorded in the treatment of throughout protection (13.52 %) followed by protection during reproductive period (13.76 %). These two treatments were at par with each other. Both these treatments were significantly superior to rest of the treatments.

During 2001-2002, all the treatments were found significantly superior over control in reducing fruit infestation. Minimum fruit infestation (10.57%) was recorded in the treatment of throughout protection (thiamethoxam @ 4 g a.i. /kg seed treatment followed by spinosad 48 SC @ 750 ml/ha). It was followed by the protection during reproductive period only (11.26 %). Both these treatments were at par with each other. Among different treatments, the highest infestation was recorded in the protection during vegetative period only (21.62%).

Table 24. Infestation of fruit borer in different growth periods of okra

Treatment	Per cent fruit infestation		
	2000-2001	**2001-2002**	**Pooled**
T_1 -Protection during vegetative stage only	24.58 (29.65)*	21.62 (27.64)	23.10 (28.64)
T_2 - Protection during reproductive stage only	13.76 (21.70)	11.26 (19.49)	12.51 (20.59)
T_3 - Protection throughout growth period	13.52 (21.50)	10.57 (18.85)	12.04 (20.17)
T_4 -Untreated throughout growth period	37.76 (37.88)	33.53 (35.34)	35.64 (36.61)
SE ±	0.56	0.67	0.41
CD at 5 %	1.74	2.06	1.14

* - Figures in parentheses are angular transformed values

The pooled data for the year 2000-2001 and 2001-2002 revealed that all the treatments were significantly superior over control. The least fruit infestation was recorded in the treatment of throughout protection (12.04 %) and protection during reproductive period (12.51 %) and both these treatments were at par with each other. The treatments of protection during vegetative period only recorded highest fruit infestation (23.10%) among different treatments. The untreated control recorded 35.64 % fruit infestation.

4.6.5. Effect on plant height and per cent avoidable loss due to key pests during various growth periods of okra

The data regarding influence of various treatments on plant height and per cent avoidable loss are presented in Table 25 and Fig. 12.

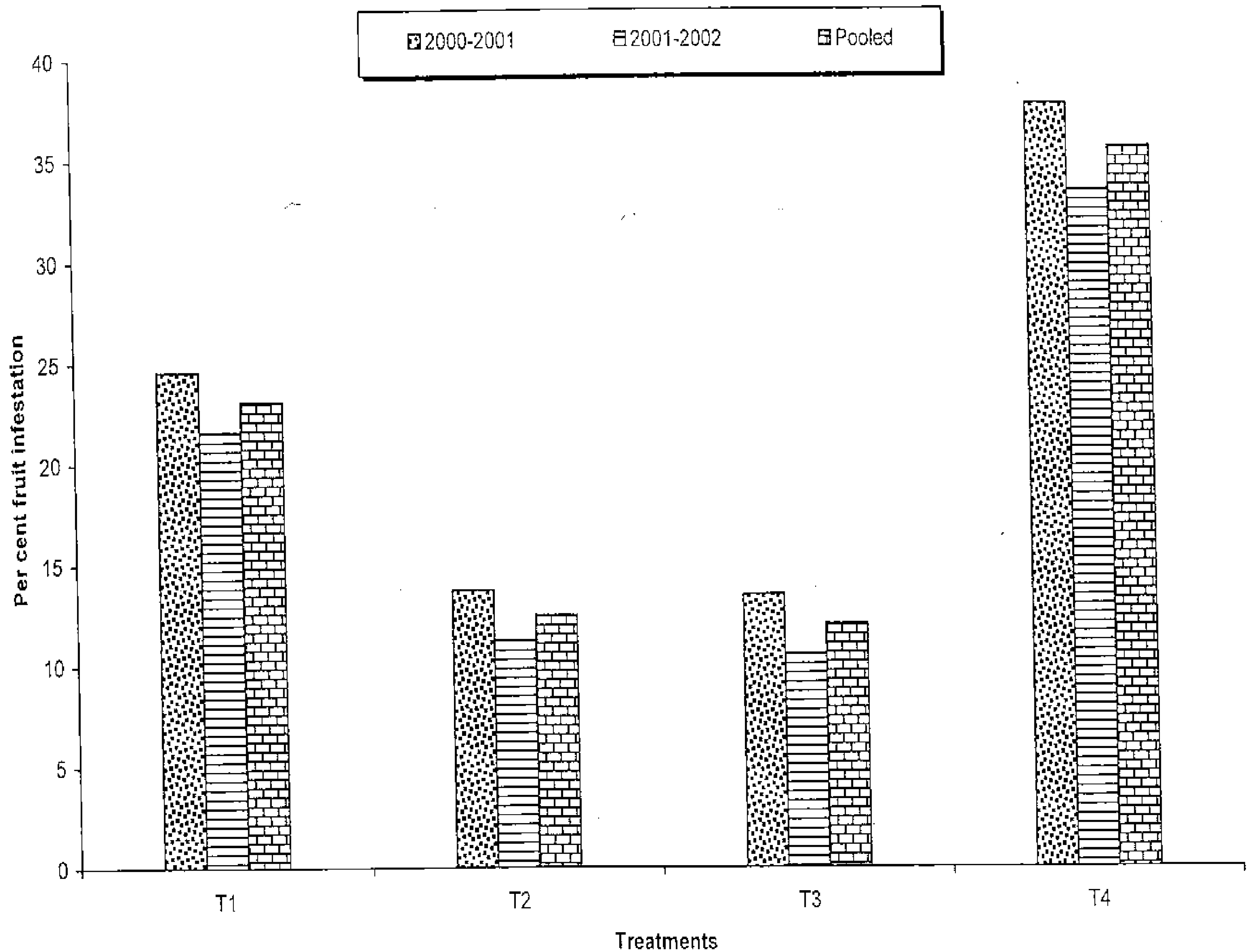


Fig. 11. Infestation of fruit borer

Table 25. Plant height and per cent avoidable loss due to insect pests in different growth periods of okra

Treatment	2000-2001		2001-2002		Pooled	
	Mean plant height at final harvest (cm)	Per cent avoidable loss	Mean plant height at final harvest (cm)	Per cent avoidable loss	Mean plant height at final harvest (cm)	Per cent avoidable loss
T_1 -Protection during vegetative stage only	61.58	4.14	63.46	3.68	62.52	3.90
T_2 - Protection during reproductive stage only	58.40	9.09	61.24	7.05	59.82	8.05
T_3 - Protection throughout growth period	64.24	Nil	65.89	Nil	65.06	Nil
T_4 -Untreated throughout growth period	53.79	16.26	56.07	14.90	54.93	15.57
SE ±	1.31		0.95		0.76	
CD at 5 %	4.04		2.94		2.12	

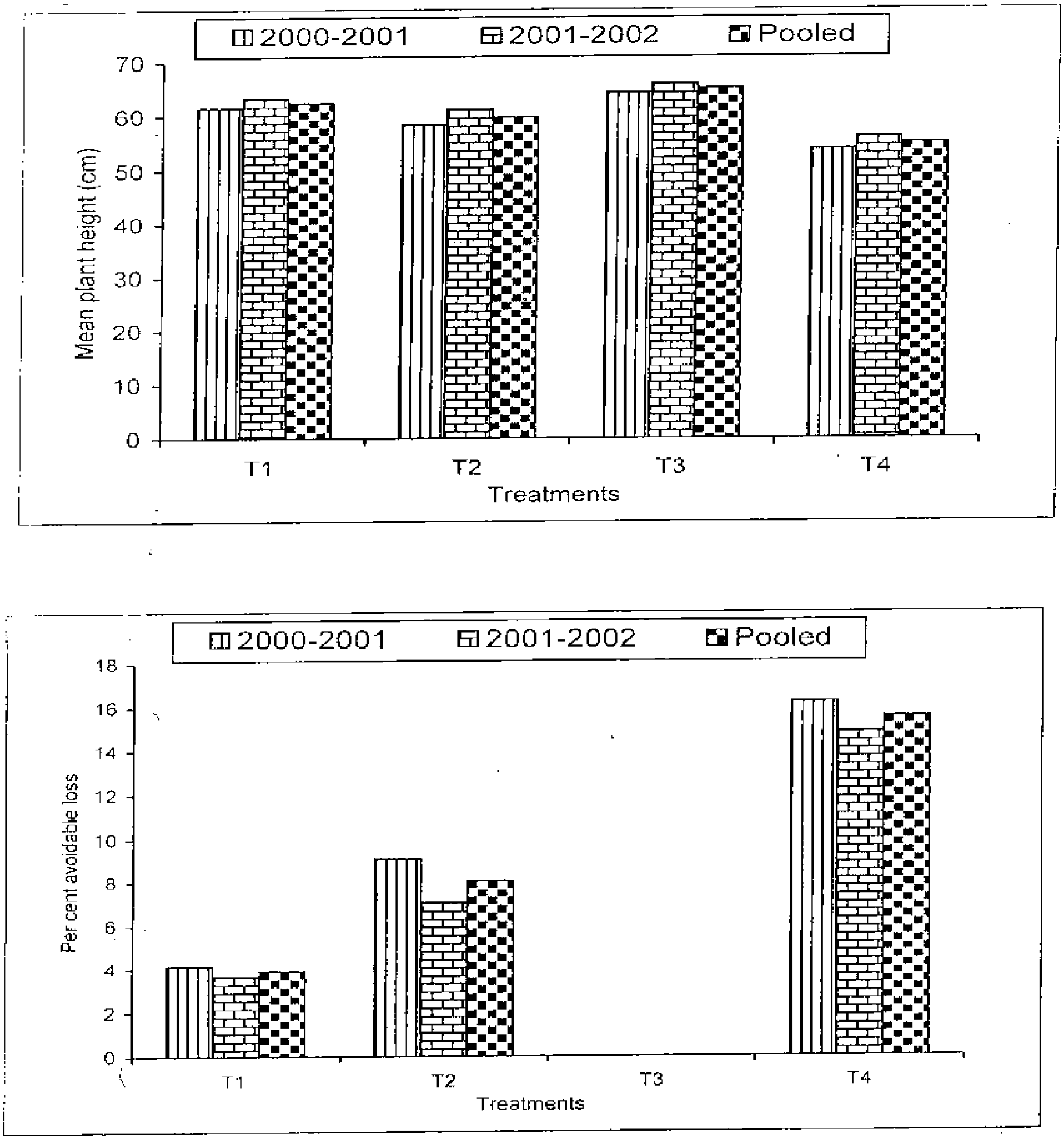


Fig. 12. Plant height and per cent avoidable loss.

4.6.5.1. Effect on plant height

The results obtained during both the years were significant. The treatment of throughout protection recorded maximum height of 64.24 and 65.89 cm in 2000-2001 and 2001-2002, respectively. It was followed by the treatment of protection during reproductive period only (61.58 and 63.46 cm, respectively) and protection during vegetative period only (58.10 and 61.24 cm in 2000-2001 and 2001-2002, respectively), which were at par with each other. All the treatments recorded significantly more height over control.

The pooled data for the year 2000-2001 and 2001-2002 indicated that all the treatments were significantly superior over control. The maximum height (65.06 cm) was recorded in the treatment of throughout protection (T_3).

It was followed by protection during vegetative period only (62.52 cm) and protection during reproductive stage only (59.82 cm). The control treatment recorded 54.93 cm plant height.

4.6.5.2. Per cent avoidable loss in plant height

Table 25 indicated that during 2000-2001, the reduction in plant height in unprotected plot (T_4) was to the extent of 16.26 per cent. Avoidable loss in plant height was minimum in the treatment receiving protection throughout growth period (nil) followed by protection during vegetative period (4.14 per cent) and protection during reproductive period (9.09 per cent).

During 2001-2002, avoidable loss in plant height in untreated control (T_4) was to the extent of 14.90 %. Minimum avoidable loss (3.68 %) was recorded in the treatment of protection during vegetative period (T_1) followed by protection during reproductive period (8.05 %).

4.6.6. Effect on number of leaves per plant and per cent avoidable loss due to key pests during various growth periods of okra

The data on influence of various treatments on number of leaves per plant and per cent avoidable loss are presented in Table 26 and Fig. 13.

4.6.6.1. Effect on number of leaves per plant

The differences in number of leaves /plant at final harvest were non-significant during both the years of investigation and in respect of treatments in pooled data of two years.

During both the years and for pooled data, numerically the lowest number of leaves/ plant were observed in unprotected control (T_4) (9.16, 9.12 and 9.14 leaves/plant, respectively). Maximum number of leaves were observed in the treatments of throughout protection (T_3) (10.48, 10.24 and 10.36 leaves /plant, respectively during 2000-2001, 2001-2002 and pooled data).

4.6.6.2. Per cent avoidable loss in number of leaves per plant

The number of leaves were not affected by the okra pest complex. The pooled data (Table 26) indicated that per cent avoidable loss was minimum in the treatment of throughout protection (nil) followed by treatment of protection during vegetative period (2.50 %) and protection during reproductive period (4.05 %).

4.6.7 Effect on average leaf area (cm^2) and per cent avoidable loss due to key pests during various growth periods of okra

The data on influence of various treatments on average leaf area and per cent avoidable loss are presented in Table 27 and Fig. 14.

4.6.7.1 Effect on average leaf area (cm^2)

The differences in average leaf area at 40 DAS (days after sowing) were non-significant during both the years of study and in respect pooled results.

Table 26. Number of leaves per plant and per cent avoidable loss due to insect pests in different growth periods of okra

Treatment	2000-2001		2001-2002		Pooled	
	Mean No. of leaves /plant at final harvest	Per cent avoidable loss	Mean No. of leaves /plant at final harvest	Per cent avoidable loss	Mean No. of leaves /plant at final harvest	Per cent avoidable loss
T_1 -Protection during vegetative stage only	10.20	2.67	10.00	2.34	10.10	2.50
T_2 - Protection during reproductive stage only	10.08	3.81	9.80	4.29	9.94	4.05
T_3 - Protection throughout growth period	10.48	Nil	10.24	Nil	10.36	Nil
T_4 -Untreated throughout growth period	9.16	12.59	9.12	10.93	9.14	11.77
SE ±	0.73		0.47		0.80	
CD at 5 %	NS		NS		NS	

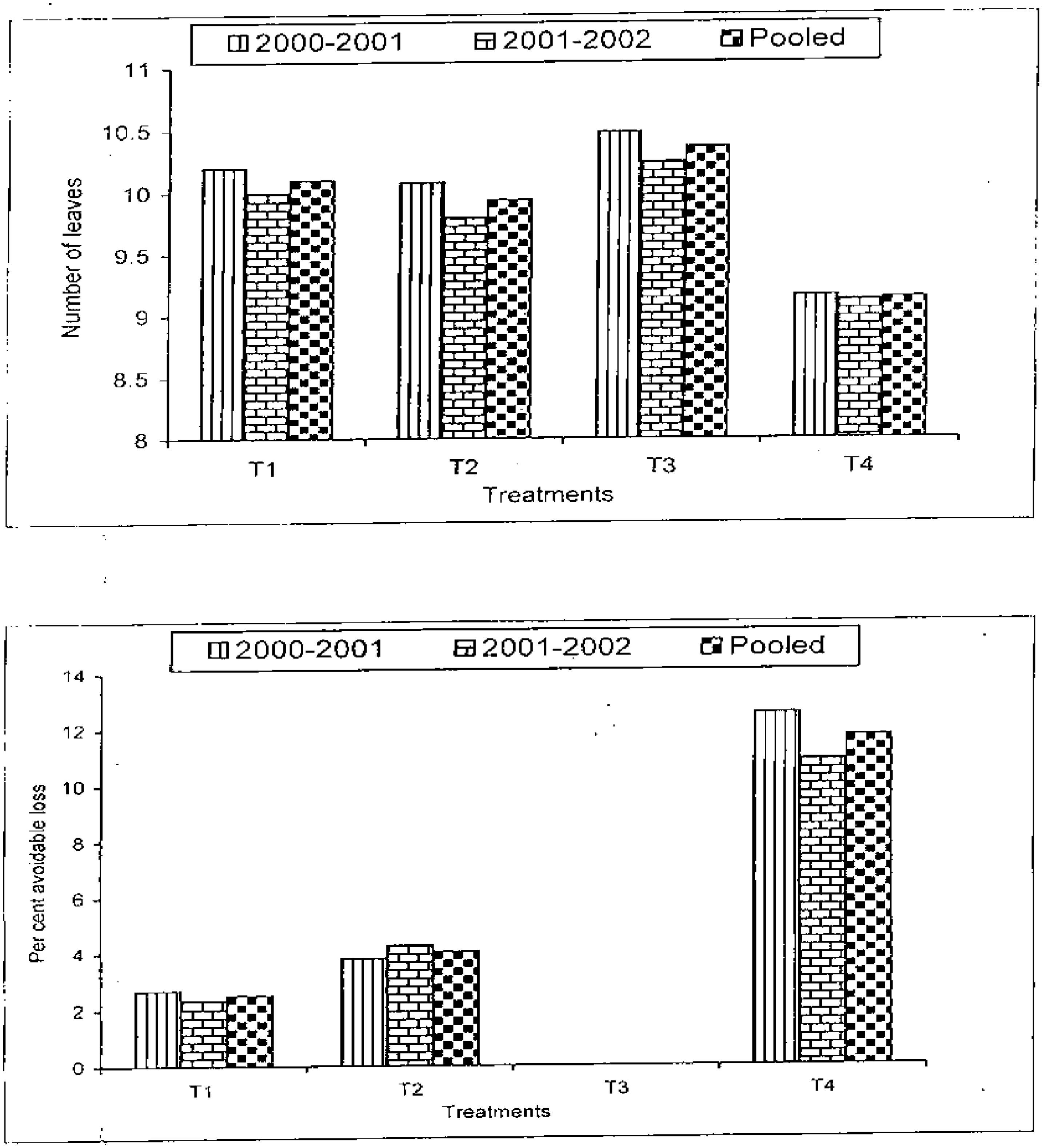


Fig. 13. Number of leaves per plant and per cent avoidable loss

Table 27. Average leaf area (cm^2) and per cent avoidable loss due to insect pests in different growth periods of okra

Treatment	2000-2001		2001-2002		Pooled	
	Avg. leaf area (cm^2)	Per cent avoidable loss	Avg. leaf area (cm^2)	Per cent avoidable loss	Avg. leaf area (cm^2)	Per cent avoidable loss
T_1 -Protection during vegetative stage only	103.26	Nil	106.32	Nil	103.35	Nil
T_2 - Protection during reproductive stage only	98.52	4.59	101.65	4.39	98.60	4.59
T_3 - Protection throughout growth period	101.71	1.50	104.31	1.89	101.78	1.51
T_4 -Untreated throughout growth period	98.77	4.34	100.48	5.49	98.81	4.39
SE $\pm$	1.37		1.35		1.33	
CD at 5 %	NS		NS		NS	

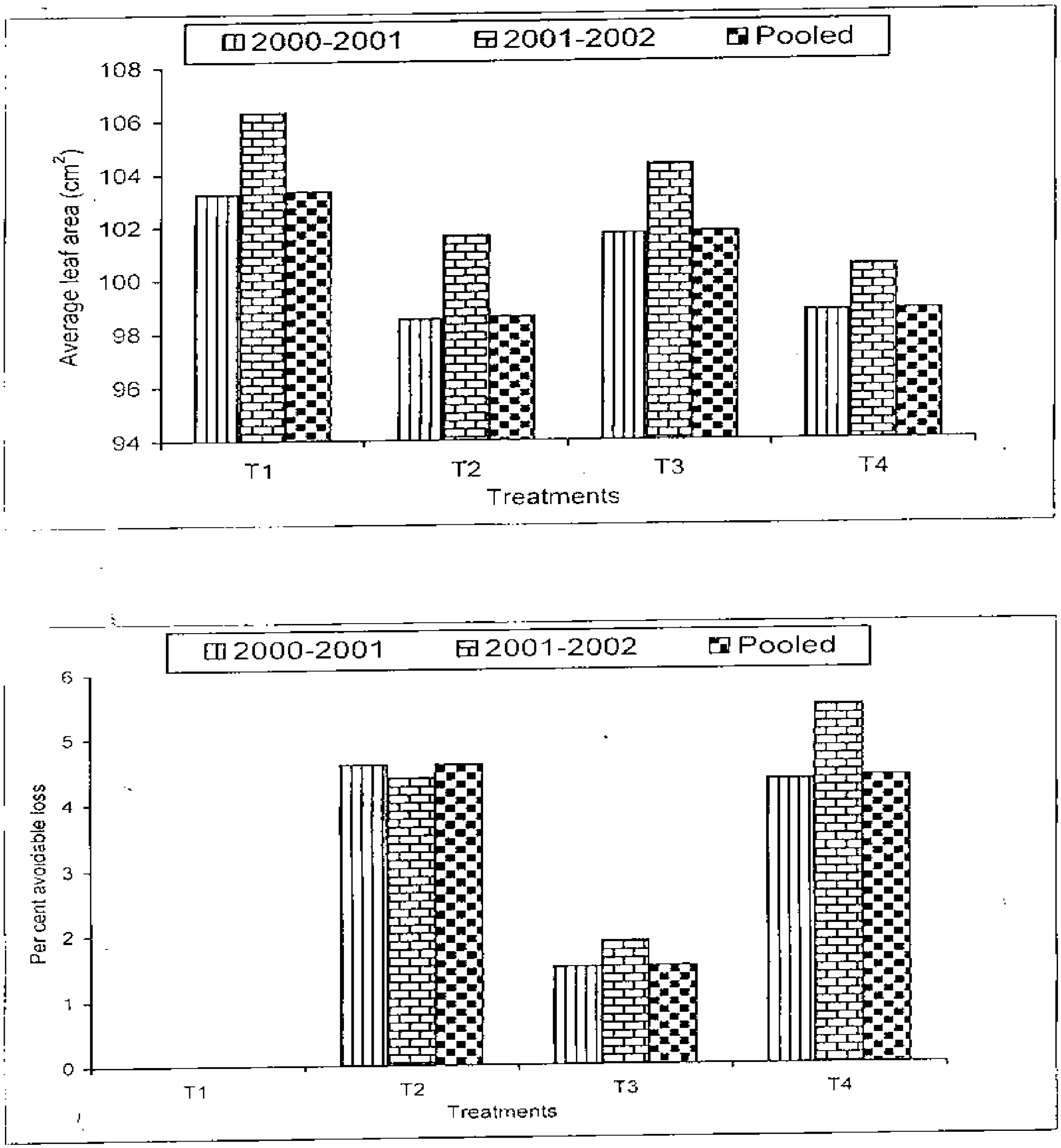


Fig. 14. Average leaf area (cm^2) and per cent avoidable loss.

During both the years and for pooled data, comparatively highest leaf area was observed in the treatment T_1 i.e. treatment receiving protection during vegetative period (103.26, 106.32 and 103.35 cm^2, respectively). During 2000-2001, the lowest leaf area (98.52 cm^2) was recorded in T_2 (protection during reproductive period only) whereas during next year, the lowest leaf area (100.48 cm^2) was recorded in T_4 (untreated control).

4.6.7.2 Per cent avoidable loss in average leaf area (cm^2)

Though there were differences in average leaf area, it was not much affected by the various treatments as the results indicated non-significant differences (Table 27).

During 2000-2001, the highest per cent avoidable loss (4.59) was recorded in T_2 (treatment receiving protection during reproductive period only) followed by untreated control (4.34 per cent). During 2001-2002, the highest avoidable loss of 5.49 per cent was observed in untreated control and it was followed by the treatment receiving protection during reproductive period only (4.39 per cent).

4.6.8 Effect on average fresh leaf weight and per cent avoidable loss due to pests during various growth periods of okra

The data pertaining to influence of various treatments on average fresh leaf weight and per cent avoidable loss are presented in Table 28 and Fig.15.

4.6.8.1 Effect average fresh leaf weight

The differences in average fresh leaf weight were non significant during both the years and in respect of pooled data.

During 2000-2001, numerically maximum fresh leaf weight was recorded in the treatment of protection during vegetative period (2.61 g /leaf) followed by the treatment of throughout protection (2.29 g/leaf).

Table 28. Average fresh leaf weight and per cent avoidable loss due to insect pests in different growth periods of okra

Treatment	2000-2001		2001-2002		Pooled	
	Average fresh leaf weight (g)	Per cent avoidable loss	Average fresh leaf weight (g)	Per cent avoidable loss	Average fresh leaf weight (g)	Per cent avoidable loss
T_1 -Protection during vegetative stage only	2.61	Nil	2.80	5.72	2.70	Nil
T_2 - Protection during reproductive stage only	2.24	14.24	2.71	8.75	2.47	8.51
T_3 - Protection throughout growth period	2.29	12.32	2.97	Nil	2.63	2.59
T_4 -Untreated throughout growth period	2.24	14.24	2.53	14.81	2.38	11.85
SE $\pm$	0.13		0.19		0.21	
CD at 5 %	NS		NS		NS	

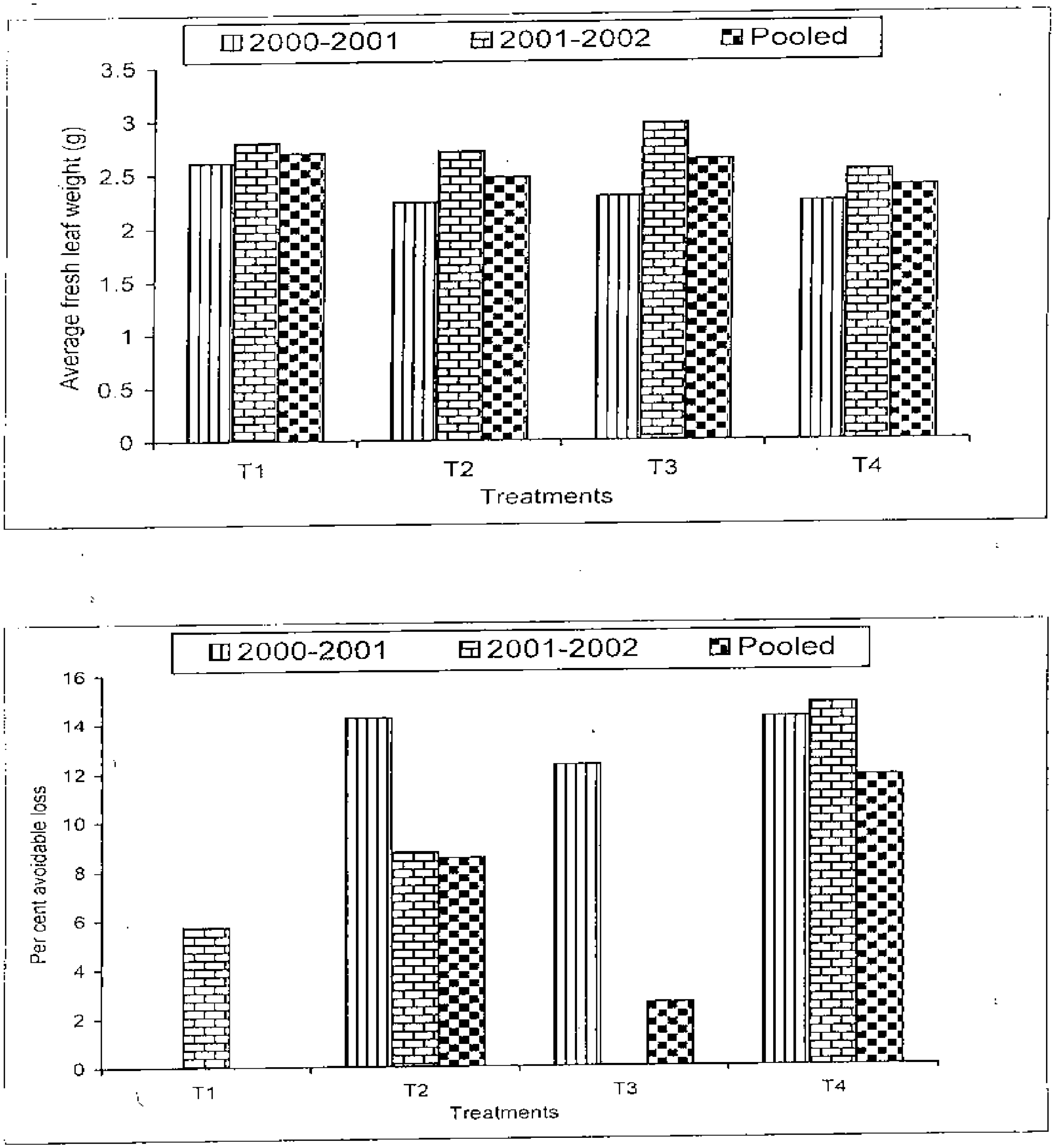


Fig. 15. Average fresh leaf weight and per cent avoidable loss

During 2001-2002, the maximum average fresh leaf weight was recorded in the treatment of throughout protection (2.97 g/leaf) followed by the treatment of protection during vegetative period (2.80 g /leaf). Lowest average fresh leaf weight was recorded in untreated control (2.53 g/leaf).

The pooled data for the year 2000-2001 and 2001-2002 indicated that maximum average fresh leaf weight was recorded in the treatment of protection during vegetative period (2.70 g/leaf) followed by the treatment of throughout protection (2.63 g/leaf). The lowest average fresh leaf weight recorded in the untreated control (2.38 g /leaf).

4.6.8.2 Per cent avoidable loss in average fresh leaf weight

The okra pest complex did not affect the average fresh leaf weight. The pooled data (Table 28) indicated that minimum per cent avoidable loss was observed in the treatment of protection during vegetative period (T_1) (Nil) followed by the treatment of throughout protection (2.59 %) and protection during reproductive period (8.51 %). The maximum per cent avoidable loss was recorded in the treatment of untreated control (11.85 %).

4.6.9 Effect on marketable fruit yield and per cent avoidable loss due to key pests during various growth periods of okra

The data regarding influence of different treatments on marketable fruit yield and per cent avoidable loss are presented in Table 29 and Fig. 16.

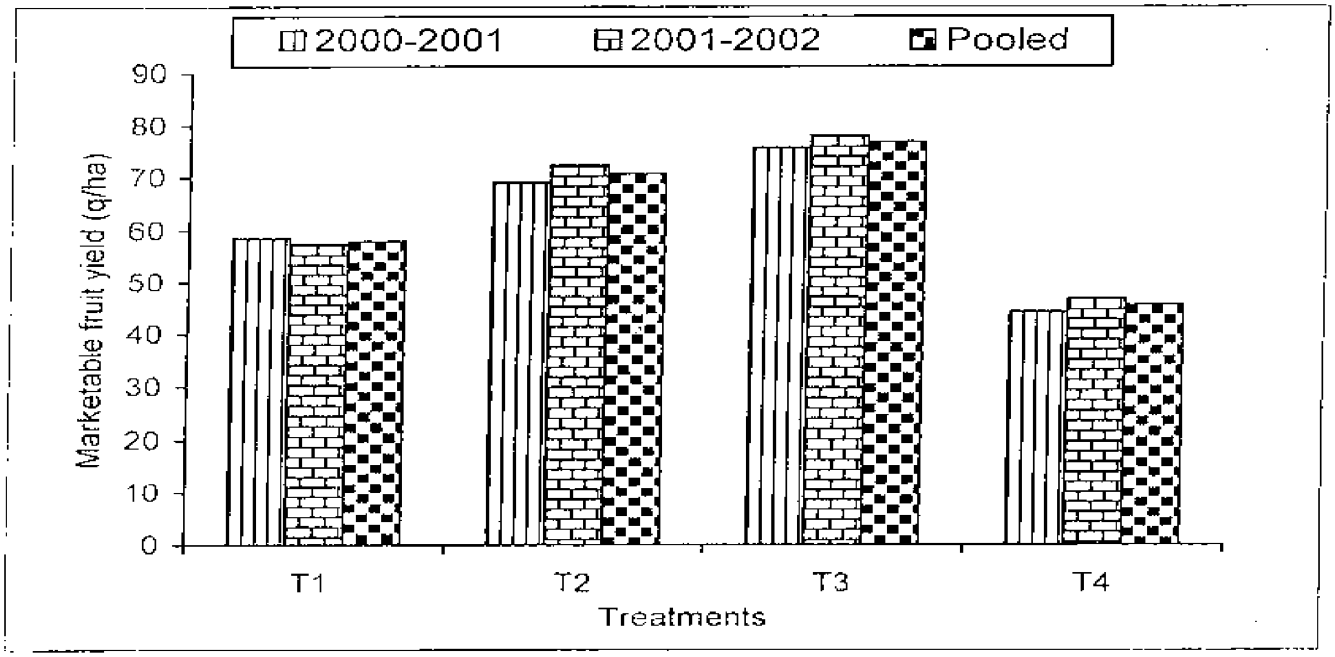
4.6.9.1 Effect on marketable fruit yield

The results obtained during both the year and pooled data were significant.

During 2000-2001, the maximum yield (75.80 q/ha) was recorded in the treatment of throughout protection (T_3) followed by the treatment of protection during vegetative period (69.15 q / ha) and

Table 29. Marketable fruit yield and per cent avoidable loss due to insect pests in different growth periods of okra

Treatment	2000-2001		2001-2002		Pooled	
	Marketable fruit yield (q/ha)	Per cent avoidable loss	Marketable fruit yield (q/ha)	Per cent avoidable loss	Marketable fruit yield (q/ha)	Per cent avoidable loss
T_1 -Protection during vegetative stage only	58.60 ^{c}	24.15	57.49 ^{c}	26.24	58.07 ^{c}	24.57
T_2 - Protection during reproductive stage only	69.15 ^{b}	8.77	72.50 ^{b}	7.27	70.82 ^{b}	8.01
T_3 - Protection throughout growth period	75.80 ^{a}	Nil	78.19 ^{a}	Nil	76.99 ^{a}	Nil
T_4 -Untreated throughout growth period	44.40	41.68	47.00	39.89	45.70	40.64
SE $\pm$	1.18		1.09		1.50	
CD at 5 %	3.63		3.37		4.15	



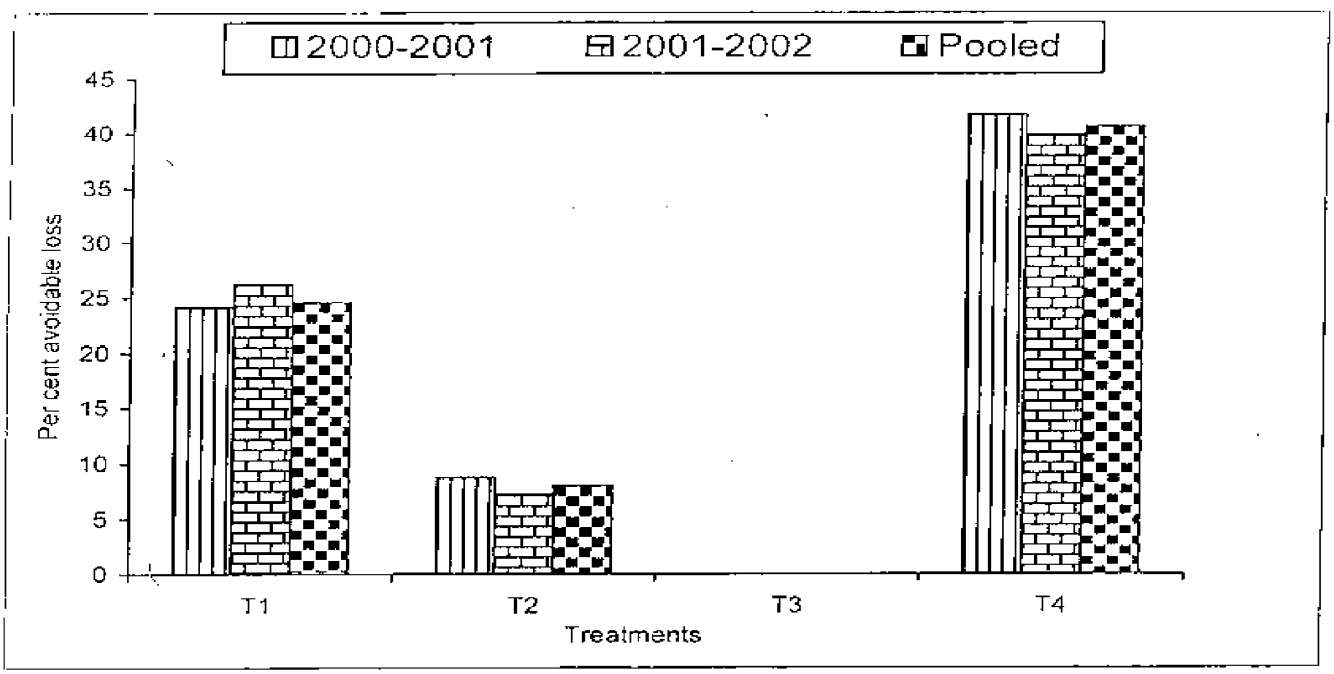


Fig. 16. Marketable fruit yield and per cent avoidable loss

protection during vegetative period (58.66 q/ha). The untreated control recorded the lowest marketable fruit yield (44.40 q/ha).

During 2001-2002, the marketable fruit yield ranged between 47.00 to 78.19 q/ha. The highest yield was recorded in the treatment of throughout protection (78.19 q/ha) followed by protection during reproductive period (72.60 q/ha) and protection during vegetative period (57.49 q/ha).

The pooled data (Table 29) revealed that the highest marketable fruit yield was observed in the treatment of throughout protection (79.99 q/ha) followed by protection during vegetative period (70.82 q/ha) and protection during vegetative period (58.07 q/ha). The lowest marketable fruit yield was recorded in the untreated control (45.70 q/ha).

4.6.9.2 Per cent avoidable loss in marketable fruit yield

The data from Table 29 indicated that the per cent avoidable loss was minimum (nil) in the treatment of throughout protection during reproductive period (T_2) (8.77 %, 7.27 % and 8.01 %, respectively during 2000-2001, 2001-2002 and pooled). It was followed by the treatment of protection during vegetative period (24.15 %, 26.24 % and 24.50 %, respectively). The maximum per cent avoidable loss was recorded in the untreated control (41.68 %, 39.89 % and 40.64 % during 2000-2001, 2001-2002 and pooled data, respectively).

DISCUSSION

CHAPTER-IV

DISCUSSION

Okra (*Abelmoschus esculenus* (L.) Moench) is an important vegetable crop grown round the year. The yield of okra is seriously hampered due to ravages of insect pests. Sucking pest complex and the fruit borer have been a very serious problem in the economic cultivation of okra. Study of population dynamics plays a key role in deciding the management strategy of pests. Hence in present study population dynamics of okra pest was studied and their correlation with abiotic factors was worked out. Many insecticides have been tried in the past for the control of okra pests with varying degree of success. Present investigations were carried out to study the bio-efficacy of some newer insecticides as seed dressers and spray along with conventional insecticides. Nevertheless, the chemical insecticides have some adverse effect on natural enemies of the pests. This point was considered and attempt was made to study the effect of insecticidal application on larval parasitoids of *E. vittella*. Also the crop losses caused by key pests during various growth periods of okra were studied.

The results obtained are discussed in the light of the previous work under following heads.

5.1. Population dynamics of key pests of okra

5.2. Bioefficacy of newer insecticides against key pests of okra

5.3. Effect of different insecticidal treatments on marketable fruit yield of okra

5.4. Economics of various treatment applications in okra pest management

5.5. Effect of different insecticidal treatment on larval parasitization of *Earias vittella*

5.6. Crop loss assessment due to key pests during various growth periods of okra

5.1. Population dynamics of key pests of okra

5.1.1. Population dynamics of aphids

The observations on population fluctuations of okra aphid, *Aphis gossypii* during summer season of 2000-2001 indicated that the aphid population ranged between 0.00 to 16.10 aphids/ three leaves. The first appearance of aphid was noticed in 10th meteorological week (0.05 aphids/ three leaves) when the corresponding rainfall, maximum-minimum temperature, morning-evening relative humidity and bright sunshine hours were 0.00 mm, 34.8°C, 16.6°C, 55 %, 26 % and 10.5 hours/ day, respectively. Thereafter, the population increased steadily and reached its peak (16.10 aphids/three leaves) in 18th meteorological week (30 April to 6 May). During 2001-2002, the aphid population starts rising steadily from 0.05 in 10th MW to the highest of 16.10 aphids/three leaves /plant in 18th MW with increasing temperature. Then during 19th and 20th MW it slightly lowered and reached to 12.56 aphids/three leaves when the prevailing rainfall maximum-minimum temperature, morning-evening relative humidity and bright sunshine hours were 0.8 mm, 40°C, 26.6°C, 43 %, 24 % 11 hours/day, respectively.

These trends of aphid infestation were more or less similar to those reported by other research workers. Patel and Rote (1995) reported that population of *A. gossypii* peaked (43.05 /plant) in the second fortnight of October. Jamwal and Kandoria (1990) recorded 450 aphids /30 plant as highest on *kharif* okra. Devasthali and Saran (1997) reported that okra crop was infested by aphids from the age of 11 days till maturity.

Further they noted that the infestation period of aphid was 49 days and weekly mean population density was 18.32 aphids/ three leaves. Jarande (1998) reported that the incidence of aphids on okra varied from 0.40 to 23 aphids/ three leaves /plant. Telang *et al.* (2003) observed very high (10.25 to 170.90 aphids / 3 leaves) population of aphids (*A. gossypii*) due to high humidity ranging from 64.14 to 86.14 % during 1999-2000 while negligible (0.00 to 3.30 /3 leaves) in next season.

5.1.2. Population dynamics of jassids

During first year of study (2000-2001), the incidence of jassids started in 9th MW recording 0.10 jassids/three leaves when the prevailing abiotic factors i.e. rainfall, maximum-minimum temperature, morning-evening relative humidity and bright sunshine hours were 0.00 mm, 35.4°C, 16.4°C, 60 %, 28 % and 11.0 hours /day, resp. Afterwards the jassid population rose steadily upto 14th MW (16.50 jassids/three leaves). A small decrease was observed in the next week (11.90/3 leaves). This might be due to the sudden rise in the humidity from 47 % in 14th MW to 60 % in the 15th MW. Thereafter the population increased slowly and reached to peak of 25.10 /three leaves during 18th MW when the rainfall, maximum-minimum temperature, morning-evening relative humidity and bright sunshine hours were 0.00 mm, 43.2°C, 24.5°C, 33 %, 17 % and 11.6 hours /day, respectively. Then the population decreased very slowly upto the removal of the crop.

In the next year, the jassid attack started in 10th MW recording 0.40 jassids/three leaves. In the 11th MW, the jassid population decreased somewhat (0.10 /three leaves) and thereafter it increased steadily with increase in temperature.

From 16th MW onwards, the jassid population increased somewhat fastly and reached to a peak of 21.20 jassids/ three leaves.

Thereafter the population remained more or less steady upto the end of crop.

Srinivasan *et al.* (1981) reported that rainfall was found to reduce the mean density and increased aggregation of *Amrasca biguttulla biguttulla* on okra. The absolute maximum temperature also caused an increase in aggregation. Dhamdhere *et al.* (1985) observed that *A. biguttulla biguttulla* remained active throughout both seasons in *kharif* and summer of 1980-81. Low humidity in 1980 appeared to be conducive to population build-up. Lal *et al.* (1990) reported *A. biguttulla biguttulla* on two weeks-old okra crop which increased with age of crop except 2nd half of the fourth and fifth weeks because of heavy rainfall (61.1 mm), low temperature (< 29°C), high RH (>78 %) and less sunshine (6.4 hr) which reduced pest population by 72.6 per cent. Patel *et al.* (1997) reported that the population of *A. biguttulla biguttulla* increased during monsoon season when temperature remained around 37°C along with at least ten hours of bright sunshine. Jarande (1998) recorded 0.50 to 39.95 jassids/three leaves whereas Mahmood *et al.* (1998) observed peak population of 27.8 jassids /leaf in late July on okra.

From the foregoing discussion, it is evident that the jassid population remained active throughout the age of the okra crop. While increasing temperature and decreasing humidity favours the population build-up of *A. biguttulla biguttalla,* rainfall and increasing humidity adversely affects the population. These trends found in the present investigation are in confirmation with the findings of above researchers.

5.1.3. Population dynamics of whitefly

During 2000-2001, the first appearance of whiteflies was noticed in the 9th MW (0.60/ three leaves). In the next week, the population decreased slightly to 0.30 whiteflies / three leaves. Thereafter the population increased steadily and recorded highest population of 9.20

whiteflies/ three leaves in 18th MW when the prevailing rainfall, maximum - minimum temperature, morning -evening relative humidity and bright sunshine hours were 0.00 mm, 43.2°C, 24.5°C, 33 %, 17 % and 11.6 hours /day, respectively. Thereafter the population decreased very slowly. During next year (2001-2002), the whitefly population ranged between 0.60 to 8.40 whiteflies /three leaves. The lowest population (0.60 / three leaves) was recorded in the 10th MW. After 10th MW, the population rose slowly and reached to peak (8.40 / three leaves) in 18th MW (30th April to 6th May). Overall, it is observed that the whitefly population increases with increase in temperature. The population remained steady i.e. around 6/ three leaves from 12th MW to 15th MW when the morning relative humidity was stable around 50 %.

Murugesan *et al.* (1977) found highly significant positive correlation between maximum temperature and whitefly incidence. They further reported that rainfall and relative humidity were negatively associated with whitefly incidence. Bhardwaj and Kushwaha (1984) reported peak infestation of *B. tabaci* in October and March. Jarande (1998) reported 0.45 to 0.90 whiteflies/ three leaves. Kumawat *et al.* (2000) observed that whitefly infestation started in the fourth week of July and peak population was observed in the fourth week of September. Telang *et al.* (2003) recorded highest whitefly population (4.35/ three leaves) in 14th and 18th MW in 1999-2000 and in 10th and 11th MW in 2000-2001 (2.70 whiteflies / three leaves). The trends in the population of whiteflies observed in the present investigation are in agreement with the findings of above research workers.

5.1.4. Population dynamics of *E. vittella*

From the data pertaining to per cent fruit infestation by *E. vittella* during summer seasons of 2000-2001 and 2001-2002, it is evident that during first year, the overall fruit infestation ranged between 15.01 to

57.80 per cent. The lowest fruit infestation was recorded in the 14th MW (2nd April to 8 April) when the prevailing rainfall, maximum-minimum temperature, morning-evening relative humidity and bright sunshine hours were 11.0 mm, 36.2°C, 20.5°C, 60 %, 31 % and 9.1 hours/day, respectively. Thereafter the fruit infestation increased to 27.20 % in 15th MW. The rainfall and high relative humidity (60 %) might have restricted the fruit infestation in 14th MW. From 18th MW, fruit infestation remained more or less constant upto the end of the crop whereas during the next season, the infestation ranged between 25.85 to 51.30 per cent. The fruit infestation increased with increase in temperature and reached to the peak of 51.30 % during 18th MW. From 17th MW, the fruit infestation remained steady until the end of the crop.

In Maharashtra, Mote (1977) reported presence of *E. vittella* on okra after six weeks of the germination in *kharif* and summer seasons. He further noted that the pest intensity in summer rapidly increased and reached to its peak (69.91 per cent). Radke and Undirwade (1981) noted mean maximum, minimum and average temperature 29.4°C, 12.2°C, and 20.8°C, respectively with an average relative humidity of 53.2 per cent during severe attack of *E. vittella* on okra. Dhawan and Sidhu (1984) reported that maximum damage was caused due to *Earias* spp. to okra fruits (67.7 per cent) in late October. They further stated that heavy rainfall adversely affected population build-up of *E. vittella*. Pawar *et al.* (1996) reported that there was significant negative correlation of *E. vittella* population and relative humidity, rainfall and wind velocity. The crop sown on 15th May and 1st June had a lower incidence (17.9 to 18.6 %) of fruit borer Shukla *et al.* (1997) observed a peak infestation of 41.25 % before harvesting in the first fortnight of June. Zala *et al.* (1999) reported that bright sunshine hours, and maximum mean temperature favoured the build-up of *E. vittella* activity. The pest became active when the crop was 3 to 4 week old and remained active throughout the crop growth.

The findings of the above researchers supported the outcome in the present investigation.

5.1.5. Correlation and regression studies between weather parameters and aphids

The pooled results of correlation and regression coefficients between weather factors and aphid population brought out significant positive correlation with maximum and minimum temperature (r = 0.835** and 0.821**, respectively). The correlation of aphid population with morning relative humidity was significant but negative (r = -0.667**) whereas that of with evening relative humidity, it was negative and non significant. Rest of the weather parameters showed non-significant correlation with the aphids. The simple regression equations worked out for maximum-minimum temperature and morning relative humidity were y = -55.28 + 1.674x, y = -14.42 + 1.160x and y = 30.61-0.4285x, respectively indicating an increase of 1.67 and 1.16 and a reduction of 0.4285 in aphid population for every unit increase in the above meteorological parameters.

Telang *et al.* (2003) observed significant positive correlation only with maximum temperature and aphid during 1999-2000 and 2000-2001 (r = 0.966** and 0.891**, respectively supporting the findings of the present study. Though above correlations of weather parameters were observed with the aphid population, the overall aphid incidence was low during both the seasons of study hence further confirmation is needed.

5.1.6. Correlation and regression studies between weather parameters and jassid population

The data on jassid population showed that during first year of study (2000-2001), only maximum temperature.showed significant positive correlation (r = 0.836**) whereas during next year jassid population showed positive significant correlations with maximum and minimum temperature (r = 0.866** and 0.859**, respectively). The pooled analysis brought out significant positive correlation between maximum and minimum temperature (r = 0.748** and 0.847**) with jassid population whereas morning relative humidity showed significant but negative association. Remaining weather parameters showed non-significant impact on the jassid population. The simple regression equations worked out for maximum, minimum temperature and morning relative humidity were $y = -84.18 + 2.428\ x$, $y = -30.24 + 1.937\ x$ and $y = 41.20 - 0.6379\ x$ which revealed that for every unit increase in maximum and minimum temperature, the jassid population increased by 2.428 and 1.937, respectively whereas for every unit increase in morning relative humidity, the pest population decreased by 0.6379.

Srinivasan *et al.* (1981) reported that rainfall was found to reduce the mean density (negative correlation) and increase aggregation of *A. biguttulla biguttulla* on okra. The absolute maximum temperature also caused an increase in aggregation (positive correlation) Mahmood *et al.* (1990) reported that among various environmental factors, maximum and minimum temperature showed positive correlation with density of jassids on okra. They further reported that neither relative humidity nor rainfall significantly increased or decreased the pest population. Pawar *et al.* (1996) reported that there was significant positive correlation of okra jassid and maximum temperature and bright sunshine hours. Patel *et al.* (1997) observed significant positive relationship between *A. biguttulla biguttulla* population level and maximum temperature (r = 0.76) as well as hours of bright sunshine (r = 0.82). All the above workers supported the findings of present study. Sharma and Sharma (1997) found positive correlation between minimum temperature and jassid number supporting the findings of present study but further he reported negative correlation with maximum temperature and average RH contradictory to the findings of present study.

5.1.7. Correlation and regression studies between weather parameters and whitefly population

During 2000-2001, only maximum temperature showed positive significant correlation with whitefly population (r = 0.841**). Rest of the weather parameters showed non-significant association with whitefly population. Whereas during next year of study (2001-2002) maximum and minimum temperature showed positive significant correlation with whitefly population (r = 0.925** and 0.819**, respectively). The pooled analysis brought out significant positive association between whitefly number and maximum and minimum temperature (r = 0.854** and 0.844**, respectively) whereas morning relative humidity showed significant but negative correlation with whitefly population (r = -0.663**).

Murugesan *et al.* (1977) found highly significant positive correlation between maximum temperature and whitefly incidence. They further reported that rainfall and relative humidity were negatively associated with whitefly incidence. Lal and Pillai (1982) found significant and positive relationship between maximum temperature and population of whitefly whereas rainfall and relative humidity were negatively associated, although their relationship was non-significant.

Bhardwaj and Kushwaha (1984) reported that the association between whitefly and maximum temperature was positive and significant, while that of relative humidity was negatively significant. Rao and Reddy (1987) observed significant negative association between whitefly incidence and all the weather factors. Latpate (1987) found significant and negative association between whitefly incidence and weather factors *viz.*, rainfall, relative humidity, mean temperature and wind velocity. Telang *et al.* (2003) found significant positive correlation between whitefly population and maximum temperature (r = 0.958 and 0.905, respectively) during 1999-2000 and 2000-2001 whereas significant negative (r = -0.666) between morning relative humidity and whitefly population. The findings of the present study are in confirmation with the earlier workers.

5.1.8. Correlation and regression studies between weather parameters and per cent fruit infestation by *E. vittella*

The data on per cent fruit infestation and correlation and regression coefficients revealed that during 2000-2001, only maximum temperature showed significant positive correlation (r = 0.80**) with per cent fruit infestation whereas, during 2001-2002, maximum and minimum temperature showed significant positive association (r = 0.80** and 0.80**, respectively). Rest of the abiotic factors showed non-significant correlation. The pooled results brought out significant positive association between per cent fruit infestation and maximum and minimum temperature (r = 0.818** and 0.877**, respectively). The morning relative humidity showed significant but negative relationship with per cent fruit infestation. Rest of the weather factors showed non-significant relationship. The simple regression equations worked out for maximum - minimum temperature and morning relative humidity were y = 236.9 + 6.662 x, y = -82.98 + 5.031x and y = 100.8 - 1.620x, respectively.

Kumar and Urs (1988) reported that infestation of *E. vittella* on okra was higher in warmer months than in rainy or cooler months. There was a significant positive correlation of the pest population with temperature and negative correlation with relative humidity. The rainfall did not show any correlation with the pest population, confirming the results of the present study. Negative correlation between *E. vittella* infestation and RH was also earlier reported by Kadam and Khaire (1995) and Pawar *et al.*(1996). Shukla *et al.* (1997) reported that mean maximum temperature and percentage fruit damages were significantly correlated in both the years with regression equations of y = -99.46 + 3.121 x (1993) and y = -62.54 + 2.2167 (1994) as found in the present study. The significant positive correlation between *E. vittella* infestation and max. and mean temperature was also reported by Zala *et al.* (1999) who further also reported significant negative correlation between RH and larval activity confirming the results of present study. But Gupta *et al.* (1998a) found contradictory results with the present findings who correlated percentage fruit infestation of okra with *E. vittella* on a weight basis with weather factors and observed that percentage infestation was positevely correlated with min. temperature (r = 0.82), morning RH (r = 0.79), evening RH (r = 0.88) and total rainfall (r = 0.34), and negatively correlated with max. temperature (r = -0.6194).

5.2. Bioefficacy of newer insecticides against key pests of okra

5.2.1. Bioefficacy of seed dressers against sucking pests of okra

5.2.1.1. Bioefficiacy of seed dressers against aphids , *A. gossypii*

The pooled results for the year 2000-2001 and 2001-2002 revealed that all the treatments were significantly superior over control in reducing the aphid population.

The per leaf aphid population on 15 DAS (days after sowing) ranged from 0.13 to 2.10 aphids /leaf. The most effective treatments in controlling aphids were of thiamethoxam @ 4 g a.i./kg seed (T_4, T_5 and T_6) followed by imidacloprid @ 10 g a.i. /kg (T_3) which were at par with each other. Among different treatments, the least effective treatments were of carbofuran 3 G @ 5 % seed treatment (T_8, T_7 and T_9). The untreated control recorded 2.10 aphids/leaf.

The observations on 25 DAS indicated that all the treatments recorded significantly lower population of aphids than untreated control. The aphid population ranged between 1.43 to 5.20 aphids /leaf. The treatments of thiamethoxam @ 4 g a.i. /kg seed (T_5, T_4 and T_6) proved most effective and recorded 1.43, 1.83 and 1.99 aphids/leaf, respectively. All these treatments were at par with each other. The next best treatments were of imidacloprid @ 10 g a.i./kg seed (T_1, T_3 and T_2). These treatments remained at par with each other by recording 2.40, 2.33 and 2.53 aphids/leaf. The carbofuran 3 G @ 5 per cent seed treatments (T_7 , T_8 and T_9) proved least effective in controlling the aphids.

Aphid population on 35 DAS ranged from 3.76 to 6.46 aphids /leaf. All the treatments were significantly superior over control. The treatments of thiamethoxam @ 4 g a.i. /kg seed (T_6, T_5 and T_4) and imidacloprid @ 10 g a.i. /kg seed treatment (T_2 and T_3) were at par with each other. The least effective treatments were of carbofuran 3 G @ 5 per cent seed treatment (T_7, T_9 and T_8). The untreated control recorded highest number (6.46/leaf) of aphids than all the treatments.

The effectiveness of thiamethoxam and imidacloprid was reported by several workers. Senn *et al.* (1998) in their laboratory studies and filed trials indicated that dose rates of thiamethoxam, between 10 and 200 g a.i./ha applied as foliar /seed treatment, were sufficient for controlling aphids. Katyare (1999) reported that considering efficacy, persistence and economy, lower dose of imidacloprid and thiamethoxam i.e. 0.5 per cent for seed dressing and 0.00125 per cent for spraying were effective in checking aphid population on okra.

De-Proft *et al.* (1999) evaluated effects of seed treatment in several crops and reported that efficacy of thiamethoxam was at par with imidacloprid. Nakat *et al.* (2002) evaluated imidacloprid 70 WS@ 0.2, 0.3 and 0.5 per cent and thiamethoxam @ 0.2, 0.3 and 0.5 per cent against sucking pests (aphids and jassids) of green gram and reported that the treatments with 0.5 per cent concentration were most effective. They further reported that when two chemicals were compared with each other, thiamethoxam (70WS) was found to be superior to imidacloprid (70 WS) in all respects. Vadodaria *et al.* (2001 b) also reported that seed treatment with thiamethoxam at 4.3 and 2.8 g/kg seed, imidacloprid 600 FS at 12 and 9 ml/kg, and imidacloprid 70 WS at 7.5 g/kg kept the population of aphids below economic threshold level on cotton upto 50 days after germination. Sreelatha and Divakar (1997) showed that seed treatment with imidacloprid 7.5 g/kg of okra seed effectively controlled aphids. Wang *et al.* (1995) also effectively controlled cotton aphid with imidacloprid.

Palanisamy (1971) could control okra aphid upto 93 per cent with carbofuran 10 G. @1.0 kg a.i./ha. The efficacy of carbofuran against sucking pests of okra was also reported by Murthy *et al.* (1996) and Kumar Rishi *et al.* (1996), Kumar *et al.* (1989) reported that application of carbofuran 3 G at 1 kg a.i./ha at the time of sowing did not give effective control of sucking pests of okra (jassids and aphids) at the later crop stages.

It is evident from the foregoing discussion that thiamethoxam and imidacloprid gave effective control of the aphids on okra. Carbofuran was found comparatively less effective. The results of present investigation are in agreement with the results of above researchers.

5.2.1.2. Bioefficacy of seed dressers against jassids, *A. biguttulla biguttulla*

The pooled observations on the population of jassids indicated that all the treatments were significantly superior over control on 15, 25 and 35 DAS. Jassid population on 15 DAS ranged between 0.03 to 1.36 jassids/leaf. The most effective treatment was T_5 (thiamethoxam @ 4 g a.i./kg seed) which recorded 0.03 jassids /leaf. Carbofuran 3 G @ 5 per cent seed treatments (T_8 and T_9) recorded 0.76 and 1.10 jassids/ leaf, respectively and proved to be least effective. Imidacloprid @ 10 g a.i./kg seed treatments (T_1, T_2 and T_3) were intermediate in efficacy against jassids.

The data on 25 DAS indicated that the most effective treatments were of thiamethoxam @ 4 g a.i. /kg seed (T_4 and T_6) followed by imidacloprid @ 10 g a.i. /kg seed (T_2) which were at par with each other. The least effective treatment was T_9 (Carbofuran 3 G @ 5 per cent seed treatment) which recorded 3.40 jassids/leaf. Rest of the treatments were intermediate and at par with each other.

The jassids population increased in all the treatments on 35 DAS when compared to the population on 25 DAS. The jassid population in different treatments indicated similar results as on 25 DAS. The most effective treatments were T_4 and T_6 (thiamethoxam @ 4 g a.i./kg seed) which recorded 2.39 and 2.46 jassids/leaf and were at par with each other. The least effective treatments were of carbofuran 3 G @ 5 per cent seed treatment (T_8, T_7 and T_9). The jassid population in imidacloprid @ 10 g a.i./kg seed treatments stood intermediate and was at par with each other.

Singh *et al.* (1996) reported that imidacloprid (Gaucho 70) as a seed treatment controlled jassids, *A. biguttulla biguttulla* upto 121 days on cotton. Sreelatha and Divaker (1997) controlled okra jassids with imidacloprid @ 7.5 g/kg. They further reported that the seed treatment also contributed to avoiding two foliar sprays during the vegetative stage of okra crop. Gul (1998) screened five insecticides against *A. biguttulla biguttulla* on okra and found that imidacloprid 200 SL was the most effective in controlling jassids over a longer period.

Gupta *et al.* (1998c) reported that imidacloprid was very effective against cicadellids, even at 3 g/kg (seed treatment) and 0.005 per cent foliar treatment. Kalra *et al.* (2001) reported that thiamethoxam was most toxic i.e. 0.454 times more toxic to *A. biguttulla biguttulla* on okra. Krishnakumar *et al.* (2001) showed that thiamethoxam 25 WG was on par with imidacloprid (Gaucho 600 FS) seed treatment @ 12 ml/kg of seed in reducing the leafhopper infestation on okra. The efficacy of thiamethoxam and imidacloprid was also reported by Dhawan and Simwat (2002) and Mote *et al.* (1994). The efficacy of carbofuran against jassids was tested by Kumar *et al.* (1996), Sharma *et al.* (1995), Sucheta and Khokhar (1996) and Gaikwad and Pawar (1979).

From the foregoing discussion the toxicity of the seed dressers (thiamethoxam, imidacloprid and carbofuran) is evident and supported the findings of present investigation.

5.2.1.3. Bioefficacy of seed dressers against whiteflies, *Bemisia tabaci*

The pooled data for the year 2000-2001 and 2001-2002 showed that per leaf whitefly population on 15 DAS ranged from 0.10 to 1.23 /leaf. The most effective treatments in controlling the whitefly were of thiamethoxam @ 4 g a.i./kg seed (T_4, T_5 and T_6) and imidacloprid @ 10 g a.i./kg seed (T_1). All these treatments were at par with each other. The treatments of carbofuran 3 G @ 5 per cent seed treatment (T_7, T_8 and T_9) recorded 0.69, 0.76 and 0.76/leaf and proved to be least effective and were at par with each other.

The same trend was observed on 25 DAS and the least number of whitefly were recorded in the treatments of thiamethoxam @ 4 g a.i./kg seed (T_6, T_4 and T_5). These were followed by the treatments of imidacloprid @ 10 g a.i./kg seed (T_2). Among different treatments, carbofuran 3 G @ 5 per cent seed treatment recorded highest (1.53 whiteflies/leaf) population of whitefly. The untreated control recorded 2.10 whiteflies /leaf.

The whitefly population at 35 DAS ranged from 0.89 to 2.59 whiteflies /leaf. The lowest population (0.89/leaf) was recorded in the treatment T_5 (thiamethoxam @ 4 g a.i./kg seed). The treatment T_8 (carbofuran 3 G @ 5 % seed treatment recoded highest number (1.86/leaf) of whiteflies. Rest of the treatments were intermediate.

From above results, it is evident that, thiamethoxam @ 4 g a.i./kg seed recorded comparatively lowest population of whiteflies and proved to be the best. But these were at par with the treatments of imidacloprid @ 10 g a.i./kg seed. Carbofuran 3 G @ 5 per cent seed treatment was least effective in whitefly control.

The effectivity of thiamethoxam against sucking pest was earlier reported by Scott *et al.* (2000), Vadodaria *et al.* (2001b) Wilde *et al.* (2001), Kalra *et al.* (2001), Dhawan and Simwat (2002) and Katole *et al.* (2003). Whereas, efficacy of imidacloprid against sucking pest was reported by Singh *et al.* (1996), Sreelatha and Divakar (1997), Gul *et al.* (1998) and Patil *et al.* (2002).

Raghunath *et al.* (1987) controlled the pests of okra with application of carbofuran @ 1 kg a.i./ha along with seed and need based sprays. Senn *et al.* (1998) in their laboratory studies and field trials controlled whiteflies with thiamethoxam at dose rates between 10 and 200 g a.i./ha applied as foliar or seed treatment on cotton. Gupta *et al.* (1998c) controlled whitefly on cotton with the application of imidacloprid as a foliar spray (0.005 and 0.02 per cent) and seed treatment (3 and 5 g /kg seed). Mote *et al.* (1994) used imidacloprid 70 WS as seed dresser on okra @ 5, 7.5, 10 and 15 g /kg seed for control of sucking pests on okra *viz.* aphids, jassids, thrips, mites and whiteflies.

From the above discussion, it is evident that the findings of present study are in accordance with the findings of earlier workers.

5.2.2. Bioefficacy of different insecticide against *E. vittella* fruit infestation (on weight basis)

The pooled data revealed that the overall fruit infestation ranged between 6.69 to 38.02 per cent (on weight basis) in various treatments. All the treatment was found significant over control in reducing fruit infestation. Minimum fruit infestation was observed in the treatments of profenophos + cypermethrin 44 EC @ 1000 ml/ha (6.69 and 8.34 per cent in T_2 and T_5, respectively) which were at par with each other. It was closely followed by the next treatment of profenophos + cypermethrin 44 EC @ 100 ml/ha (T_8) which recorded 9.16 per cent fruit infestation. The next best treatments in reducing the fruit infestation were of spinosad 48 SC @ 750 ml/ha (T_7, T_4 and T_1) which recorded 11.99, 12.09 and 12.53 per cent fruit infestation, respectively and were at par with each other. Among different insecticidal treatments, the least effective treatments were of monocrotophos 36 SL @ 750 ml/ha (T_6, T_3 and T_9) and all were at par with each other.

Surekha and Arjuna Rao (2000) controlled fruit borer of *bhendi* with profenophos 0.05 per cent. Srinivasan *et al.* (2001) reported that exposure of *E. vittella* larvae to profenophos revealed acute toxicity. Sivakumar *et al.* (2003) in Tamil Nadu, reported that profenophos (Curacon®) @ 2 l/ha and profenophos + cypermethrin combination (polytrin C®) @ 2 l/ha were found most effective in reducing the damage of *E. vittella* spp. as well as increasing the yield.

The efficacy of cypermethrin against fruit borer of okra, *E. vittella* was reported earlier by several researchers Nimbalkar and Ajri (1981), Pawar *et al.* (1985), Narke and Suryawanshi (1984), Patil *et al.* (1991), Toshniwal (1993), Shukla *et al.* (1996) and Panda *et al.* (1999).

Spinosad is comparatively new product, and hence there is scanty literature published on its use against fruit borer on okra. Most of the literature published on spinosad was regarding its efficacy against cotton bollworms and in some other crops. Patil *et al.* (1999) reported that spinosad at 75 and 100 g a.i. /ha resulted in minimum percentage bollworm incidence and higher yields in cotton. Dandale *et al.* (2000) found spinosad 48 % SC as most promising in controlling bollworms infesting green fruiting bodies upto 14 days after treatments. The efficacy of spinosad was also reported by Peterson *et al.* (1996), Peter *et al.* (2000), Rao *et al.* (2001), Vadodaria *et al.* (2001[a]) and Walunj *et al.* (2001).

Jadhav and Navale (1984) reported that monocrotophos 0.05 per cent applied four times at ten days interval starting from the flowering stage, was most effective in reducing the fruit borer infestation on okra. Kakar and Dogra (1988) found monocrotophos 0.05 per cent effective in controlling the okra shoot and fruit borer. Sarode and Gabhane (1994) recorded 18.16 per cent fruit infestation in okra with the treatment of monocrotophos 0.037 per cent.

Findings of the above research workers are in confirmation with the findings of present study.

5.3. Effect of different insecticidal treatments on marketable fruit yield of okra

In the present study three insecticides were used as seed dresser *viz.*, thiamethoxam @ 4 g a.i./kg seed, imidacloprid @ 10 g a. I. /kg seed and carbofuran 3 G @ 5 per cent seed treatment. These were alternated with three insecticides as spray *viz.* spinosad 48 SC @ 750 ml/ha, profenophos + cypermethrin 44 EC @ 1000 ml/ha and monocrotophos 36 EC @ 750 ml/ha. Thus there were total 9 combinations of insecticides evaluated to find out best combination effective against okra pest complex and give good yields.

The pooled data on yield for the years 2000-2001 and 2001-2002 revealed that all the combinations were significantly superior over control. The average marketable fruit yield in different combination treatments ranged between 50.40 to 83.27 q/ha. The highest yield was recorded in the treatment of thiamethoxam @ 4 g a.i./kg seed alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha (83.27 q/ha) which was at par with imidacloprid @ 10 g a.i./kg seed followed by profenophos + cypermethrin 44 EC @ 1000 ml /ha (81.70 q/ha). It was followed by thiamethoxam @ 4 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha (76.80 q/ha) and imidacloprid @ 10 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha (76.54 q/ha) and these were at par with each other. Among different treatments, the lowest yield of 64.28 q/ha was recorded in the treatment of carbofuran 3 G @ 5 per cent seed treatment alternated with monocrotophos 36 EC @ 750 ml/ha. Rest of the treatments were intermediate. The untreated control recorded 50.40 q/ha yield.

Though there is no published literature on the use of exact combinations as used in the present investigation, the perusal of the literature of following research workers revealed that the outcome of present investigation are more or less in accordance with the findings of earlier workers.

Patil *et al.* (1991) reported that cypermethrin (12.5 or 15.0 g/ha) treated plants were the least infested and gave the best yield. Toshniwal (1993) recorded higher yield with cypermethrin treatment. Peterson *et al.* (1996) reported that use of spinosad provided yields equal to the current standard programmes in cotton. Murthy *et al.* (1996) noted that the management strategy that included seed treatment with carbofuran 3 G (10 g a.i./kg) and mancozeb 75 WP (3 g a.i./kg) + application of 5 per cent neem oil soaked urea (25 kg/ha) at 30 and 50 DAS resulted in an extra marketable yield of 1.5 q/ha. Gupta *et al.* (1998b) reported that seed treatment with imidacloprid 0.5 per cent w/w followed by five sprays at 15 -day intervals with synthetic insecticides (monocrotophos 500 g a.i./ha, deltamethrin 12.5 g a.i./ha, endosulfan 750 g a.i./ha, cypermethrin 60 g a.i./ha, triazophos 600 g a.i./ha) were effective in controlling cotton pests and increased seed cotton yield. Dubey and Ganguli (1998) reported that, out of 9 treatments tested, phorate 10 G basal at 1.0 kg a.i./ha + a single spray of monocrotophos at 0.05 per cent + 4 sprays of cypermethrin at 0.006 per cent resulted in the highest fruit yield (104.23 q/ha). Panda *et al.* (1999) found that a combi-product Shrelone 29 EC (phosalone 24 per cent + cypermethrin 5 per cent) was superior in restricting fruit borer infestation and increasing fruit yield in okra. Sivakumar *et al.* (2003) observed that profenophos (Curacron®) @ 2 l/ha and profenophos + cypermethrin combination (Polythrin C®) @ 2 l/ha were most effective in reducing the damage by shoot and fruit borer, *Earias* spp. as well as in increasing the yield.

5.4. Economics of various treatment applications in okra pest management

On the basis of pooled data, it was observed that the net returns (Rs/ha) offered through application of various insecticidal combinations ranged between -9325 to 22656. The highest net returns of Rs. 22656/ha was achieved through thiamethoxam @ 4 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. It was closely followed by the treatment comprising imidacloprid @ 10 g a.i.

/kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which recorded a net return of Rs. 21060 /ha. Whereas the treatments of carbofuran 3G @ 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha, imidacloprid @ 10 g a.i./kg treatment followed by spinosad 48 SC @ 750 ml/ha and thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha recorded the net loss of Rs. 9235, 6019 and 5470 /ha.

As regards cost benefit ratio, it ranged between 1: 0.63 to 1: 7.45. The highest CBR of 1:7.45 was observed with carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. It was followed by treatment of imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which recorded net returns of Rs. 21060 /ha. Same trend was observed during both the years of study.

Pareek *et al.* (1987) reported that the treatments of fenvalerate 0.02 %, cypermethrin 0.02 %, monocrotophos 0.04 % and dimethoate 0.03 % recorded higher net profit of Rs. 4490, 4448, 4130 and 3053 /ha, respectively. Kumar *et al.* (1989) reported that the application of monocrotophos 36 EC at 500 g a.i./ha, 21.42 days after germination resulted in lower infestation of *A. biguttulla biguttulla* and *A. gossypii* on okra and the highest cost benefit ratio. Murthy *et al.* (1996) reported that the management strategy that incuded seed treatment with carbofuran 3G (10 g a.i./kg) and mancozeb 75 WP (3 g a.i. /kg) + application of 5 per cent neem oil soaked urea (25 kg /ha) at 30 and 50 DAS resulted in an extra marketable yield of 1.5 q/ha. This treatment was concluded to be the best with a cost benefit ratio of 1:4.6 and a net yield of 5.9 t/ha. The findings of the present study are in accordance with the findings of earlier workers.

But in the present study, the treatments comprising carbofuran 3 G @ 5 % seed treatment, imidacloprid @ 10 g a.i./kg seed treatment and thiamethoxam @ 4 g a.i./kg seed treatment each followed by spinosad 48 SC @ 750 ml/ha though recorded quite comparable yields with that of the highest yield, they registered a very low CBR of 1:0.63, 1:0.77 and 1:0.79, respectively. These treatments recorded the loss of Rs. 9235, 6018 and 5470 in terms of net returns. This loss can be attributed to the high cost of seed dressers (imidacloprid and thiamethoxam) and spray of spinosad 48 SC (Rs. 1100/100 ml).

5.5. Effect of different insecticidal treatments on larval parasitization of *E. vittella*

The observations pertaining to larval parasitization of *E. vittella* revealed that during both the seasons highest parasitization was recorded in the untreated control (5.33 and 3.33 per cent, respectively).

The pooled data for the year 2000-2001 and 2001-2002 indicated that the average parasitization ranged between 0.00 to 4.33 per cent. Though the untreated control recorded highest (4.33 per cent) parasitization, no significant differences were observed in various treatments. No parasitization was observed in the treatment of imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. Least parasitization (0.33 %) was observed in the treatment of carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. It was followed by the treatment of thiamethoxam @ 4 g a.i./kg seed treatment alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha (0.66 %) and carbofuran 3 G @ 5 % seed treatment followed by monocrotophos 36 SL @ 750 ml/ha (0.99 %).

The next best treatments to the parasitoid were of thiamethoxam @ 4 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750 ml/ha, carbofuran 3 G @ 5 % seed treatment alternated with spinosad 48 SC @ 750 ml/ha and imidacloprid @ 10 g a.i./kg seed treatment alternated with monocrotophos 36 SL @ 750 ml/ha which recorded 1.33, 1.66 and 1.66 per cent parasitization, respectively.

Among various treatments, the treatment of imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha and thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha recorded 1.99 and 2.33 per cent parasitization, respectively. Though there is difference in the parasitization of larva among various treatment, all the treatments showed non-significant results and hence comparable with the untreated control.

The hazards of insecticides to beneficial insects (parasites, predators and pollinators, etc.) were well documented by previous researchers (Manisagaran and Kumarsamy, 1988; Paul and Shrivastava, 1989 and Latha *et al.*, 1998).

Samasundaram and Raghupathy (1988) found that fluvalinate was least toxic to *C. blackburni* Cam. followed by deltamethrin and endosulfan. Hegde *et al.* (1987) reported that permethrin (125, 150, 200 ppm) was less toxic to parasitoid, *R. aligharensis* Quadri than cypermethrin (50 and 100 ppm), monocrotophos (700 ppm) and endosulfan (1000 ppm) tested under field conditions in 1978-80. Manoharan and Balsubramanian (1984) observed that amongst various insecticides tested for their toxicity to *C. blackburni* Cam., phsalone was least toxic to the parasitoid followed by carbaryl, endosulfan, monocrotophos, fenvalerate and dimethoate as evident from the LC_{50} value of 1.34, 0.7702, 0.4802, 0.04062, 0.03166 and 0.01062 per cent estimated for the insecticides, respectively. Miles and Dutton (2000) reported that spinosad was selective and spares the key beneficial and pollinators and is environmentally safer due to low persistence supporting the findings of present study.

From the above discussion, it is evident that, the insecticides have some adverse effect on the natural enemies of the insect pests and beneficial insects, but as the chemical insecticides are a most preferred and handy tool to the farmers, it is necessary to evaluate their safety to the natural enemies of the pests before advocating them for pest control.

5.6. Crop loss assessment due to key pests during various growth periods of okra

5.6.1. Incidence of aphids

The pooled results for the year 2000-2001 and 2001-2002 showed that thiamethoxam 4 g a.i./kg seed alternated with spinosad 750 ml/ha (throughout protection) recorded lowest aphid population of 2.38 aphids/leaf. It was followed by thiamethoxam 4 g a.i./kg seed treatment (protection during vegetative period only) which recorded 3.69 aphids /leaf and spinosad 750 ml/ha (protection during reproductive period only) (6.90 aphids/leaf). The highest aphid population (8.28 /leaf) was recorded in untreated control.

5.6.2. Incidence of jassids

Numerically lowest jassid (nymph) population (4.04 /leaf) was recorded in the treatment of thiamethoxam @ 4 g a.i./kg seed followed by spinosad 48 SC @ 750 ml/ha (throughout protection) which was at par with the treatment of thiamethoxam @ 4 g a.i./kg seed treatment (protection during vegetative period only) which recorded 4.54 jassids (nymph) /leaf. The highest jassid (nymph) population was recorded in the untreated control (9.02 jassids/leaf). It was at par with treatment of spinosad 48 SC @ 750 ml/ha (7.70 jassids/leaf) (protection during reproductive stage only.)

5.6.3. Incidence of whitefly

The pooled data on the incidence of whitefly indicated that the whitefly population ranged between 1.04 to 2.14 whiteflies/leaf in different treatments. The least whitefly population (1.04 /leaf) was observed in the treatment of thiamethoxam @ 4 g a.i./kg seed treatment (protection during vegetative period only). It was at par with the treatment receiving throughout protection (thiamethoxam @ 4 g a.i./kg seed followed by spinosad 48 SC @ 750 ml/ha) which recorded 1.06 whiteflies /leaf. The treatments of protection during reproductive period only (spinosad 48 SC @ 750 ml/ha) and untreated control recorded 2.20 and 2.14 whiteflies/leaf, respectively and were at par with each other.

From the above results, it is evident that comparatively less population of aphids, jassids (nymphs) and whiteflies were recorded in the treatments of throughout protection (thiamethoxam @ 4 g a.i./kg seed treatment alternated with spinosad 48 SC @ 750 ml/ha) and protection during vegetative period only (thiamethoxam @ 4 g a.i./kg seed). Whereas highest pest populations were recorded in the untreated control plots.

Efficacy of thiamethoxam was tested earlier by different workers against different pests on various crops. (De-Proft *et al.*, 1999, Scott *et al.*, 2000, Wilde *et al.*, 2001, Krishnakumar *et al.*, 2001 and Katole *et al.*, 2003).

Senn *et al.* (1998) in their laboratory studies and field trials indicated that dose rates of thiamethoxam, between 10 and 200 g a.i./ha applied as foliar /seed treatment, was sufficient for controlling all target insect pests such as aphids, whiteflies and thrips on cotton. Katyare (1999) reported that considering efficacy, persistence and economy, lower dose of thiamethoxam i.e. 0.5 per cent for seed dressing and 0.00125 % for spraying were effective in checking aphid, jassid population on summer okra and in governing plant growth characters and yield. Kalra *et al.* (2001) tested thiamethoxam against *A. biguttulla biguttulla* on okra and reported that thiamethoxam was 454 times more toxic than, malathion to the pest. Vadodaria *et al.* (2001b) stated that seed treatment with thiamethoxam at 4.3 and 2.8 g/kg seed kept the population of aphids, jassids and thrips below economic threshold level on cotton upto 50, 60 and 30 days after germination, respectively. They further reported that thiamethoxam enhanced the growth of cotton plants besides controlling sucking pests. Dhawan and Simwat (2002) controlled cotton jassids effectively with thiamethoxam @ 25 g a.i./ha. The findings of present investigation are in confirmation with that of the findings of above researchers.

5.6.4. Infestation of fruit borer

The pooled results pertaining to infestation of fruit borer revealed that the least fruit infestation (12.04 per cent) was recorded in the treatment which received throughout protection (i.e. thiamethoxam @ 4 g a.i./kg seed followed by spinosad 48 SC @ 750 ml/ha) and it was at par with the treatment receiving protection during reproductive period only (spinosad 48 SC @ 750 ml/ha) which recorded 12.51 per cent fruit infestation. Comparatively higher fruit infestation (23.10 per cent) was recorded in the treatment of protection in vegetative stage only (thiamethoxam @ 4 g a.i./kg seed treatments) whereas highest fruit infestation was recorded in the untreated control (35.64 %). Similar trends were obtained during both the years of investigation.

Due to scanty literature published on the efficacy of spinosad against *E. vittella* infesting okra, the above findings are discussed in the context of pests on different crops.

The use of Tracer (spinosod) in integrated pest management programmes for cotton was evaluated in the USA by Peterson *et al.* (1996). It was shown that the use of Tracer with conserved beneficial arthropods, controlled budworms (*Heliothis virescens*) and bollworms (*Heliothis zea*) in cotton, reduced square damage, minimized secondary insect pest, increased spray intervals and provided yields equal to the current standard programmes. Patil *et al.* (1999) reported that Spinosad at

75 and 100 g a.i./ha resulted in minimum percentage bollworm incidence and higher yields in cotton. Dandale *et al.* (2000) evaluated spinosad 48 per cent SC for two seasons on cotton bollworms. The pooled results indicated that Spinosad was found most promising in controlling bollworms infesting green fruiting bodies upto 14 days after treatment. Spinosad 2.5 % SC at different use rates was screened against lepidopteran pests of cabbage at NARDI Research Farm, Warnagal, Andhara Pradesh by Peter *et al.* (2000). Data revealed that spinosad at 15, 20 or 25 g a.i./ha was better in controlling diamondback month (*Plutella xylostella*), cabbage stem borer (*Hellula undalis*) and cabbage leaf webber (*Crocidolomia binotalis*). Efficacy of spinosad persisted for 7 days. Johnson *et al.* (2000) reported that acceptable control of bollworm (*Helicoverpa zea*) was achieved by Tracer 48 per cent SC (spinosad). Walunj *et al.* (2001) noted that spinosad 2.5 per cent SC (15 g a.i./ha) provided better control of diamondback moth for a period of one week and better yields of marketable cabbage heads as compared to conventional insecticides. The effectivity of spinosad in controlling bollworm on cotton was also reported by Vadodariya *et al.* (2001a) and Rao *et al.* (2001).

From the foregoing discussion, it is evident that spinosad was effective against the lepidopteran pests supporting the findings of present investigation.

5.6.5. Effect on plant height and per cent avoidable loss

The pooled data for the year 2000-2001 and 2001-2002 revealed that all the treatments were significantly superior over control in increasing the plant height. The treatment comprising thiamethoxam @ 4 g a.i./kg seed followed by spinosad 48 SC @ 750 ml/ha (throughout protection) recorded highest plant height of 65.06 cm. It was followed by the treatments receiving protection in vegetative period only (65.52 cm) (thiamethoxam @ 4 g a.i./kg seed treatment) and protection during reproductive stage only (spinosad 48 SC @ 750ml/ha) (59.82 cm). The control treatment recorded 54.93 cm plant height. Maximum avoidable loss of 15.57 per cent was observed in untreated control.

5.6.6. Effect on number of leaves per plant and per cent avoidable loss

Though the differences in number leaves/plant at final harvest were non significant during both the years of investigation and in respect of pooled data, the maximum avoidable loss of 11.77 per cent was observed in the unprotected control plots.

5.6.7 Effect on average leaf area and per cent avoidable loss

Though there were differences in average leaf area, it was not much affected by the various treatment applications as the results indicated non-significant differences during both the years and in respect of pooled data. ,

During both the years the highest leaf area was recorded in the treatment receiving protection during vegetative period only (103.26 and 106.32 cm^2, respectively). During 2000-2001, the highest avoidable loss of 4.59 per cent was recorded in the treatment T_2 (protection during reproductive period only) whereas during next year it was recorded in untreated control (5.49 per cent).

5.6.8 Effect on average fresh leaf weight and per cent avoidable loss

The differences in average fresh leaf weight was found non significant during both years and in respect of pooled data. The pooled data revealed that maximum average fresh leaf weight was recorded in the treatment of protection during vegetative period (thiamethoxam @ 4 g a.i./kg seed treatment) (2.70 g /leaf). It was followed by the treatment of throughout protection (thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha) (2.63 g /leaf). The lowest average fresh leaf weight of 2.38 g /leaf was observed in the untreated control plots. The maximum per cent avoidable loss of 11.85 per cent was recorded in the untreated control.

Rawat and Sahu (1973) carried out field tests to estimate losses in growth and yield of okra caused by *Amrasca devastans* Dist. and *Earias* sp. In one set of plots, the pests were controlled by the application of granules containing 5 per cent dimethoate at a rate of 20 kg/ha below the seed in the furrow followed by two sprays of 0.02 per cent endrin and six sprays of 0.2 per cent carbaryl at 10 days interval starting 5 weeks after sowing. Another set was left untreated. Averages losses observed in plant height, the number of leaves per plant, and the weight of healthy fruits were 49.8, 45.1 and 69 per cent respectively. Singh and Chopra (1979) reported that the per cent reduction in the average plant height, average number of leaves /plant, average number of total fruit (s)/5 plants, average weight of total fruit (s)/5 plants, average number of healthy fruit(s)/ 5 plants and average weight of healthy fruit(s)/5 plants in control plots in comparison with malathion and leptophos treated plots was 18.30, 28.57, 27.61, 27.0, 40.65 and 37.58 and 21.62, 28.57, 30.27, 29.67, 44.89 and 43.24, respectively. Suryawanshi *et al.* (2003) found that the per cent avoidable losses caused by the okra pests in plant height, leaf number /plant, fruit number /plant and marketable fruit yield in unprotected plots were 43.23, 10.77, 27.73 and 58.87 per cent, respectively. Maximum yield returns were obtained with four sprays of monocrotophos 0.04 % on 15-74 days old crop, thereafter yields were not significant.

Findings of the present study were more or less similar to the findings of above research workers confirming the results.

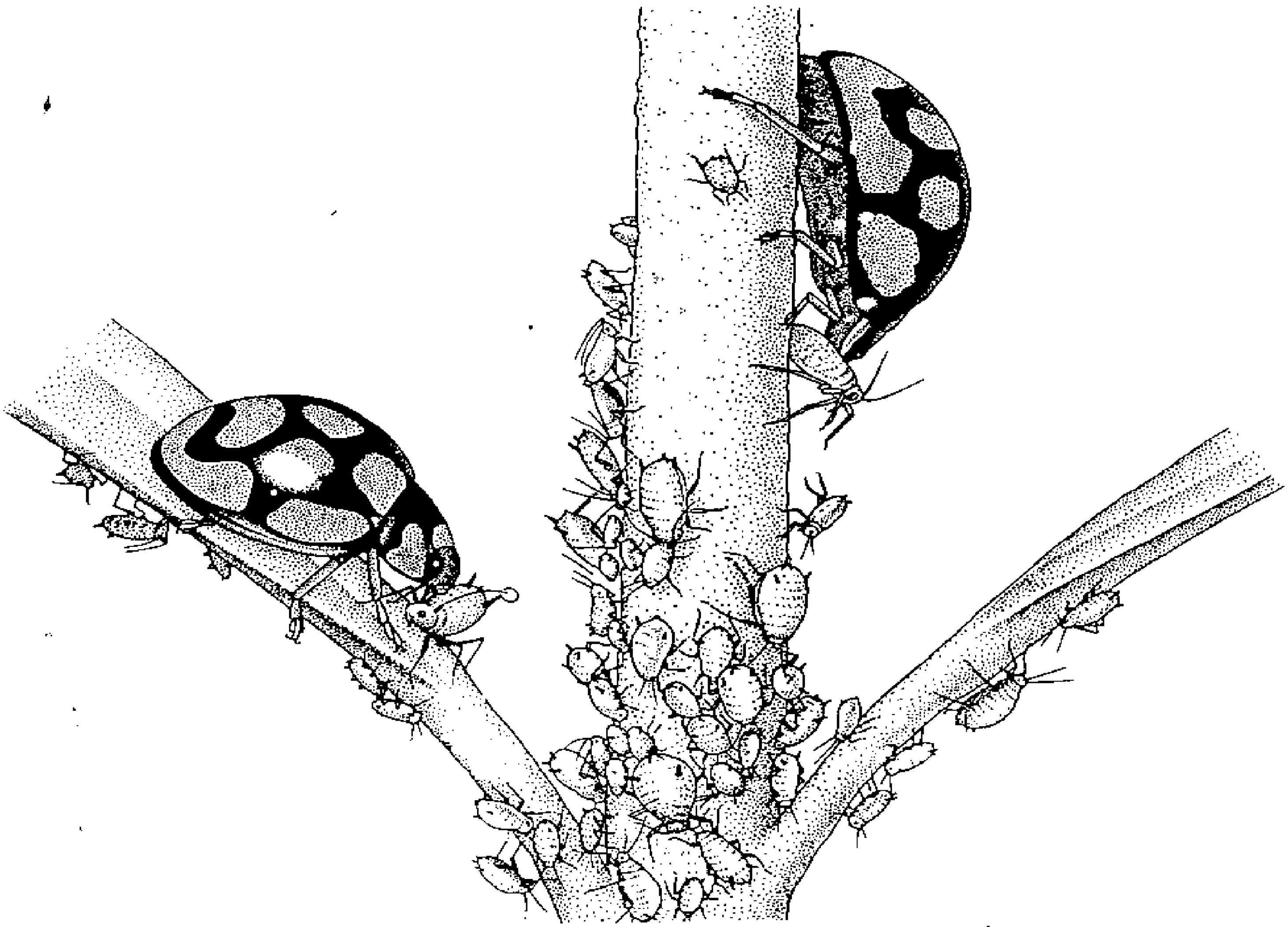
5.6.9 Effect on marketable fruit yield and per cent avoidable loss

The data on marketable fruit yield revealed that during both the year of study, highest marketable fruit yield was recorded in the treatment of thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha (throughout protection) which recorded 75.80 and 78.19 q/ha yield during 2000-2001 and 2001-2002, respectively. The next best treatments in respect of yield were that of spinosad 48 SC @ 750 ml/ha (protection during reproductive period only) which recorded 69.15 and 72.50 q/ha yield, respectively. Comparatively less yield of 58.66 and 57.49 q/ha were recorded in the treatments which received protection during vegetative period only (thiamethoxam @ 4 g a.i./kg seed treatment). Lowest yield was recorded in the untreated control in both the years (44.40 and 47.00 q/ha in 2000-2001 and 2001-2002, respectively).

Similar trend was observed in pooled results and the treatment receiving throughout protection of thiamethoxam @ 4 g a.i./kg seed followed by spinosad 48 SC @ 750 ml/ha recorded highest yield of 76.99 q/ha. Whereas untreated control recorded lowest yield of 45.70 q/ha. The untreated control recorded maximum avoidable loss in fruit yield of 41.68, 39.89 and 40.64 per cent in 2000-2001, 2001-2002 and pooled results, respectively.

Mote (1977) reported 17.31 to 37.11 and 20.69 to 69.91 per cent infestation by the *E. vittella* on okra in rainy (*kharif*) and summer seasons, respectively. Rao (1980) reported that fruit borer inflicted losses of 33.10 to 45.03 per cent by number and 21.11 to 39.26 per cent by weight with 5.40 to 13.24 q/ha reduction in yield. Krishnaiah (1980) reported that losses in okra due to leafhopper and fruit borer were 40-56 and 49-74 per cent, respectively. The fruit damage to the tune of 12.36 per cent by the pests on okra fruits was recorded during the rainy (*kharif*) season by Narke and Suryawanshi (1984). Jadhav and Nawale (1984) registered 48.25 per cent loss in the fruit yield due to the pest damage. Dhandapani (1985) estimated 9.69, 3.20, 27.73, 7.16 and 16.27 per cent loss in yield of okra fruits due to the pest infestation on okra cultivars CO-1, AE 77, AE 113, AE 180 and Pusa Sawani, respectively. He attributed the yield loss in different cultivars to their variability in susceptibility to the pest. Dhamdhere *et al.* (1985) reported that damage due to fruit borer was 25.93 to 40.91 per cent in Madhya Pradesh. Choudhary and Dadheech (1989) reported that if insecticidal protection was not given, there would be a net yield loss of 54.04 per cent Brar *et al.* (1994) observed that the losses in fruit yield of okra by *Earis spp.* were lowest (22.79 per cent) in crop sown on July 30 and maximum (50.58 per cent) in crop sown on May, 30.

From the foregoing discussion, it is evident that the losses in marketable fruit yield of okra observed in the present investigation are supported by the findings of the earlier workers.



SUMMARY

CHAPTER VI

SUMMARY

Investigations were carried out to study the population dynamics of key pests of okra, efficacy of certain newer insecticides, effect of different insecticidal treatments on larval parasitization of *E. vittella* and crop loss assessment due to key pests during various growth periods during the year 2000-2001 and 2001-2002. The results obtained are summarized below.

6.1 During 2000-2001, the aphid population ranged between 0.00 to 16.10 aphids/three leaves. The first appearance of aphid was noticed in the 10th MW (0.05 / three leaves) i. e. 5 March to 11 March. Thereafter the aphid population increased gradually and reached its peak (16.10 aphids / three leaves) in 18th MW(30 April to 6 May). Similar trend was observed during 2001-2002.The highest aphid population was observed at the end of April (16.10 aphids / three leaves). Then during 19th and 20th MW, the population decreased slightly and reached to 12.56 aphids / three leaves.

The incidence of jassids was noticed in 9th MW during 2000-2001 (0.10 jassids / three leaves). Afterwards jassid population rose steadily upto 14th MW (16.50 /three leaves). A small decrease was observed in the next week (11.90 /three leaves). Thereafter the population increased slowly and reached to peak of 25.10 /three leaves during 18th MW. In the next year, the jassid attack started in 10th MW recording 0.40 jassids /three leaves. In next week, the population decreased somewhat (0.10 / three leaves) and thereafter it increased steadily with increase in temperature. Highest population (21.20 / three leaves) was recorded in 18th MW.

During 2000-2001, the first appearance of whitefly was noticed in 9th MW (0.60 /three leaves). In the next week, the population decreased to 0.30 /three leaves. Thereafter the population increased gradually and recorded highest of 9.20 whiteflies / three leaves at the end of April. During next year (2001-2002), the whitefly population ranged between 0.60 in 10th MW to the highest of 8.40 / plant in 18th MW.

The fruit infestation due to *E. vittella* ranged between 15.01 to 57:80 during 2000-2001. The lowest fruit infestation was recorded in the 14th MW (2 April to 8 April). Thereafter the fruit infestation increased to 27.20 per cent in 15th MW. From 18th MW, the fruit infestation remained more or less constant upto the end of crop whereas during 2001-2002, the fruit infestation ranged between 25.85 to 51.30 per cent. The highest fruit infestation was recorded in the 18th MW.

The pooled analysis brought out significant positive correlation with all the pests and maximum and minimum temperature. Whereas it was significant but negatively correlated with morning relative humidity. Rest of the weather factors showed non-significant correlations with all the pests.

6.2. In field testing of insecticides, it was observed that on 15 DAS, the most effective treatment in controlling aphids was of thiamethoxam@ 4 g a. i. / kg seed which recorded 0.13 aphids per leaf and it was at par with imidacloprid @ 10 g a. i. / kg seed (0.16 aphids / leaf). Among different seed dressers, carbofuran 3 G @ 5 per cent seed treatment was found least effective which recorded 1.00 aphid / leaf. Same trend was observed on 25 and 35 DAS.

Against jassids and whitefly also, the treatment of thiamethoxam @ 4 g a.i./kg seed (T_4, T_5 and T_6) was found most effective and recorded comparatively less pest population. It was followed by the treatment of imidacloprid @ 10 g a.i./kg seed. Many a times the treatments of thiamethoxam and imidacloprid were at par with each other. Carbofuran 3 G @ 5 per cent seed treatments (T_7, T_8 and T_9) recorded comparatively more number of jassid and whiteflies and proved to be least effective.

Overall fruit infestation ranged between 6.69 to 38.02 per cent (on weight basis) in different treatments. Minimum fruit infestation was observed in the treatments of profenophos + cypermethrin 44 EC @ 1000 ml/ha (6.69 and 8.34 per cent in T_2 and T_5, respectively) which were at par with each other. The next best treatments in reducing fruit infestation were of spinosad 48 SC @ 750 ml/ha (T_7, T_4 and T_1 which recorded 11.99, 12.09 and 12.53 per cent fruit infestation, respectively). Among different insecticidal treatments, the least effective treatments were of monocrotophos 36 EC @ 750 ml/ha (T_6, T_3 and T_9).

6.3. The highest marketable fruit yield was recorded in the treatment of thiamethoxam @ 4 g a.i./kg seed alternated with profenophos + cypermethrin 44 EC @ 1000 ml/ha (83.27 q/ha). It was followed by thiamethoxam @ 4 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha (76.80 q/ha) and imidacloprid 10 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha (76.54 q/ha) and these were at par with each other. Among different insecticidal treatments, the lowest yield of 64.28 q/ha was recorded in the treatment of carbofuran 3 G @ 5 per cent seed treatment alternated with monocrotophos 36 EC @ 750 ml/ha. The untreated control recorded 50.40 q/ha yield.

6.4. Regarding economics of various treatment applications, the net returns ranged between Rs. -9235 to 22656. The highest net return of Rs. 22656 /ha was achieved through thiamethoxam @ 4 g a.i./ha followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. It was closely followed by imidacloprid @ 10 g a.i. /kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha which recorded net returns of Rs. 21060 /ha. The highest cost benefit ratio 1:7.45 was achieved with carbofuran 3 G @ 5 % seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha. The treatments comprising carbofuran 3 G @ 5 % seed treatment followed by spinosad 48 SC @ 750 ml/ha, imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 /ha and thiamethoxam @ 4 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha though recorded quite comparable yields with that of the highest yield, they registered a very low CBR of 1:0.63, 1:0.77 and 1:0.79, respectively. These treatments recorded the loss of Rs. 9235, 6018 and 5470 in terms of net returns. This loss can be attributed to the high cost of seed dressers (imidacloprid and thiamethoxam) and spray of spinosad 48 SC (Rs. 1100/100 ml).

6.5. Regarding larval parasitization of *E. vittella,* during both the years highest parasitization was recorded in untreated control (5.33 and 3.33 per cent, respectively). The pooled results revealed that the average parasitization ranged between 0.00 to 4.33 per cent. Though the untreated control recorded highest parasitization, no significant differences were observed in various treatments administered. No parasitization was observed in the treatment of imidacloprid @ 10 g a.i./kg seed treatment followed by profenophos + cypermethrin 44 EC @ 1000 ml/ha and proved as most toxic to the parasitoid. Whereas among various treatments administered, the treatment comprising thiamethoxam @ 4 g a.i./kg seed treatment alternated with spinosad 48 SC @ 750 ml/ha recorded the highest parasitization of 2.33 per cent. Imidacloprid @ 10 g a.i./kg seed treatment followed by spinosad 48 SC @ 750 ml/ha, imidacloprid @ 10 g a.i./kg seed treatment followed by monocrotophos 36 SL @ 750 ml/ha and carbofuran 3 G @ 5 % seed treatment alternated with spinosad 48 SC @ 750 ml/ha recorded 1.99, 1.66 and 1.66 per cent parasitization, respectively.

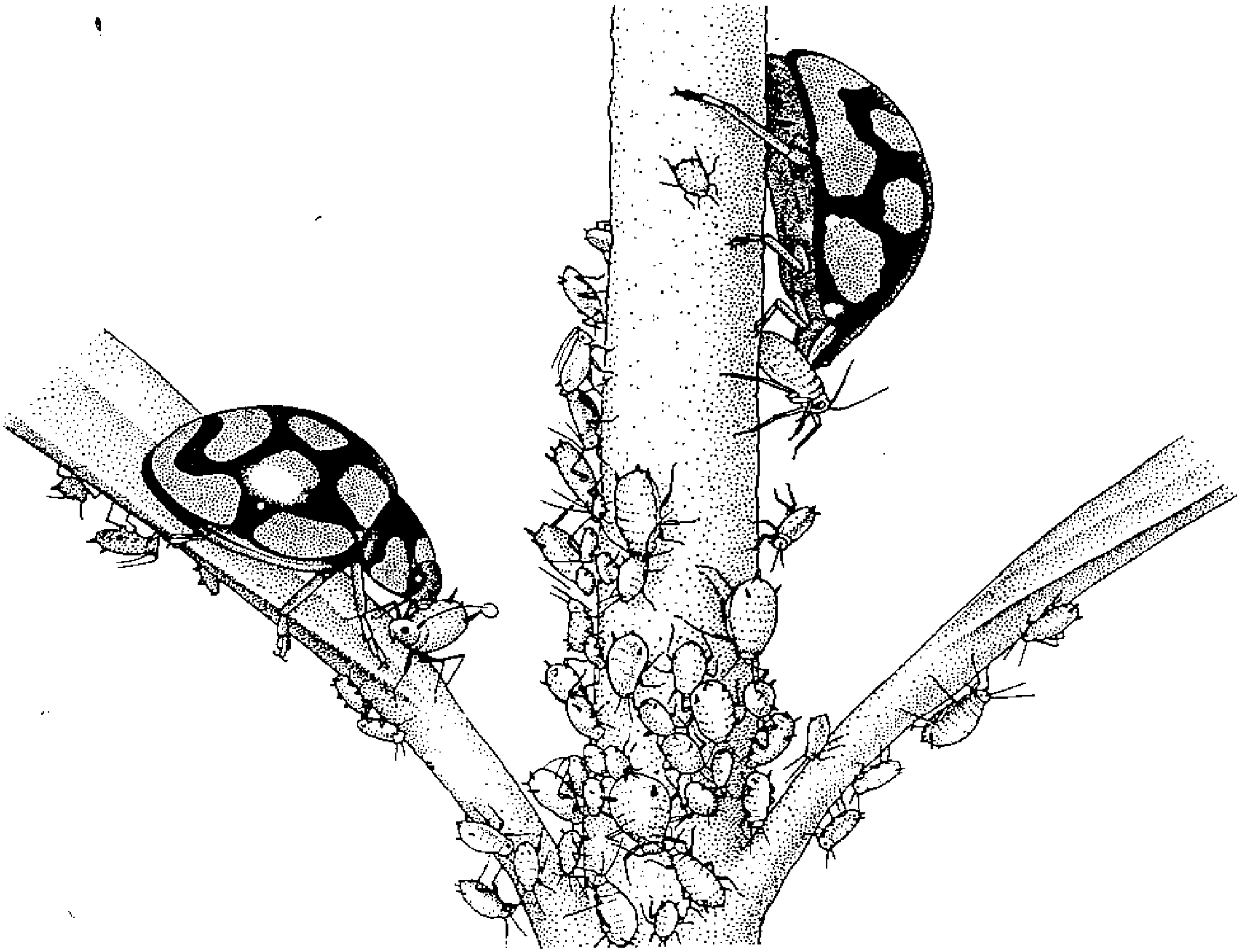
6.6. In crop loss assessment, it was observed that comparatively less population of aphids, jassids (nymphs) and whiteflies were recorded in the treatments of throughout protection (thiamethoxam @ 4 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha and protection during vegetative period only (thiamethoxam 4 g a.i./kg seed alone). Whereas highest pest populations were observed in the untreated control plots.

Least fruit infestation (12.04 per cent) was observed in the treatments receiving throughout protection and it was at par with the treatment receiving protection in reproductive period only (spinosad 48 SC @ 750 ml/ha) which recorded 12.51 per cent fruit infestation. Untreated control recorded 35.64 per cent fruit infestation.

The treatment comprising thiamethoxam @ 4 g a.i./kg seed alternated with spinosad 48 SC @ 750 ml/ha (throughout protection) recorded highest plant height of 65.06 cm whereas the differences in number of leaves /plant at final harvest were found non-significant during both the years of study and in respect of pooled results. Also the differences in average leaf area and average fresh leaf weight were found non-significant during both the years.

During both the years of investigation, highest marketable fruit yield was recorded in the treatment of thiamethoxam @ 4 g a.i./kg seed followed by spinosad 48 SC @ 750 ml/ha (throughout protection) which recorded 75.80 and 78.19 q/ha yield during 2000-2001 and 2001-2002, respectively. Lowest yield was recorded in untreated control (44.40 and 47.70 q/ha during 2000-2001 and 2001-2002, respectively).

The maximum avoidable losses caused by the okra pests in plant height, leaf number /plant, average leaf area and average fresh leaf weight/plant and marketable fruit yield were 15.57, 11.77, 4.59, 11.85 and 40.64 per cent, respectively.



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*Originals not seen.

APPENDIX I

Meteorological data (2001)

Met. Week	Rainfall (mm)	Temperature (^oC)		Relative humidity (%)		BSS (Hrs./ day)
		Max.	Min.	A.M.	P.M.	
01	1.4	26.6	10.6	75	43	8.2
02	0.0	30.2	14.2	62	30	10.0
03	0.0	31.3	16.1	72	33	9.3
04	0.0	30.3	8.6	70	26	10.5
05	0.0	32.3	11.4	73	30	10.3
06	0.0	33.6	9.5	71	24	11.3
07	0.0	33.7	12.1	66	24	11.0
08	0.0	35.2	13.8	65	26	11.2
09	0.0	35.4	16.4	60	28	11.0
10	0.0	34.8	16.6	55	26	10.5
11	0.0	36.0	17.8	55	22	10.7
12	0.0	37.7	20.0	49	20	10.7
13	0.0	37.6	17.2	47	15	11.6
14	11.0	36.2	20.5	60	31	9.1
15	0.0	36.4	21.0	46	27	8.6
16	0.0	38.0	21.8	37	29	11.4
17	0.0	41.6	23.5	35	15	11.4
18	0.0	43.2	24.5	33	17	11.6
19	0.0	42.5	25.1	35	21	12.0
20	0.8	40.0	26.6	43	24	11.0
21	0.0	39.4	25.8	47	25	10.4
22	0.0	39.0	25.9	50	28	11.7
23	5.7	36.3	24.6	77	43	6.8
24	92.8	30.5	22.5	86	61	4.3
25	2.0	33.7	23.5	76	46	7.0

APPENDIX II

Meteorological data (2002)

Met. Week	Rainfall (mm)	Temperature (^oC)		Relative humidity (%)		BSS (Hrs./ day)
		Max.	Min.	A.M.	P.M.	
01	2.2	27.3	8.2	80	36	9.7
02	31.0	27.5	10.1	87	33	10.1
03	0.0	30.5	11.9	82	35	10.7
04	0.0	30.9	11.4	68	28	10.4
05	0.0	28.7	11.7	64	35	9.6
06	29.6	30.7	16.4	83	45	8.9
07	0.0	32.2	16.5	74	34	10.5
08	0.0	32.2	16.5	74	34	10.5
09	0.0	35.9	14.9	62	18	11.1
10	0.0	36.0	15.6	54	17	10.9
11	0.0	35.6	17.0	48	24	9.6
12	0.0	38.2	16.0	51	15	10.9
13	0.0	39.0	19.2	51	21	11.3
14	0.5	39.8	21.5	53	20	10.5
15	1.4	39.2	20.4	50	18	11.0
16	0.0	41.4	26.3	43	16	9.9
17	0.0	42.2	20.9	39	14	11.9
18	0.0	43.9	26.3	40	13	10.9
19	0.0	42.3	26.6	52	20	11.8
20	11.2	41.2	26.4	63	31	9.5
21	10.1	40.6	25.0	62	28	11.4
22	1.4	40.0	23.6	57	27	10.1
23	17.2	38.2	23.8	67	36	8.6
24	23.7	36.8	21.8	78	43	8.2
25	34.0	34.3	21.8	85	56	5.9